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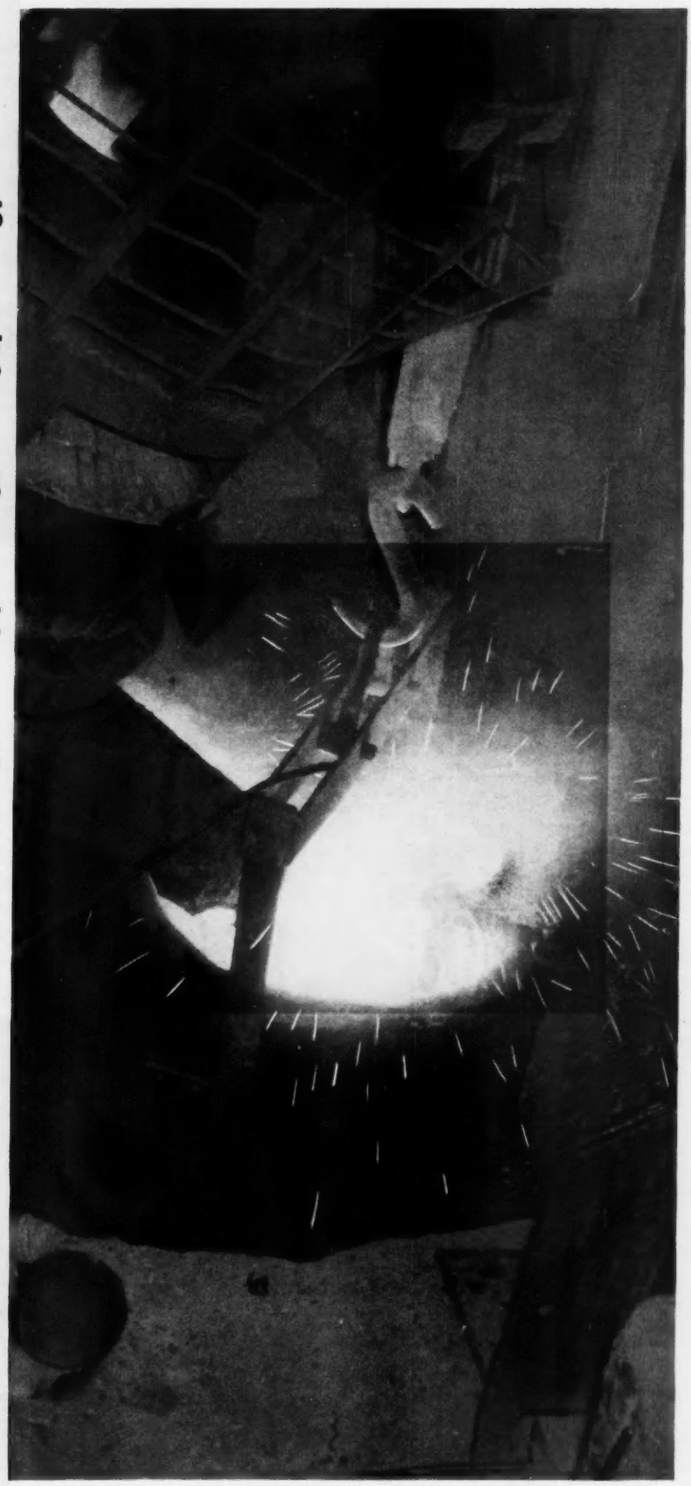

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No. 5365 **NOVEMBER 21, 1958** VOL. 206

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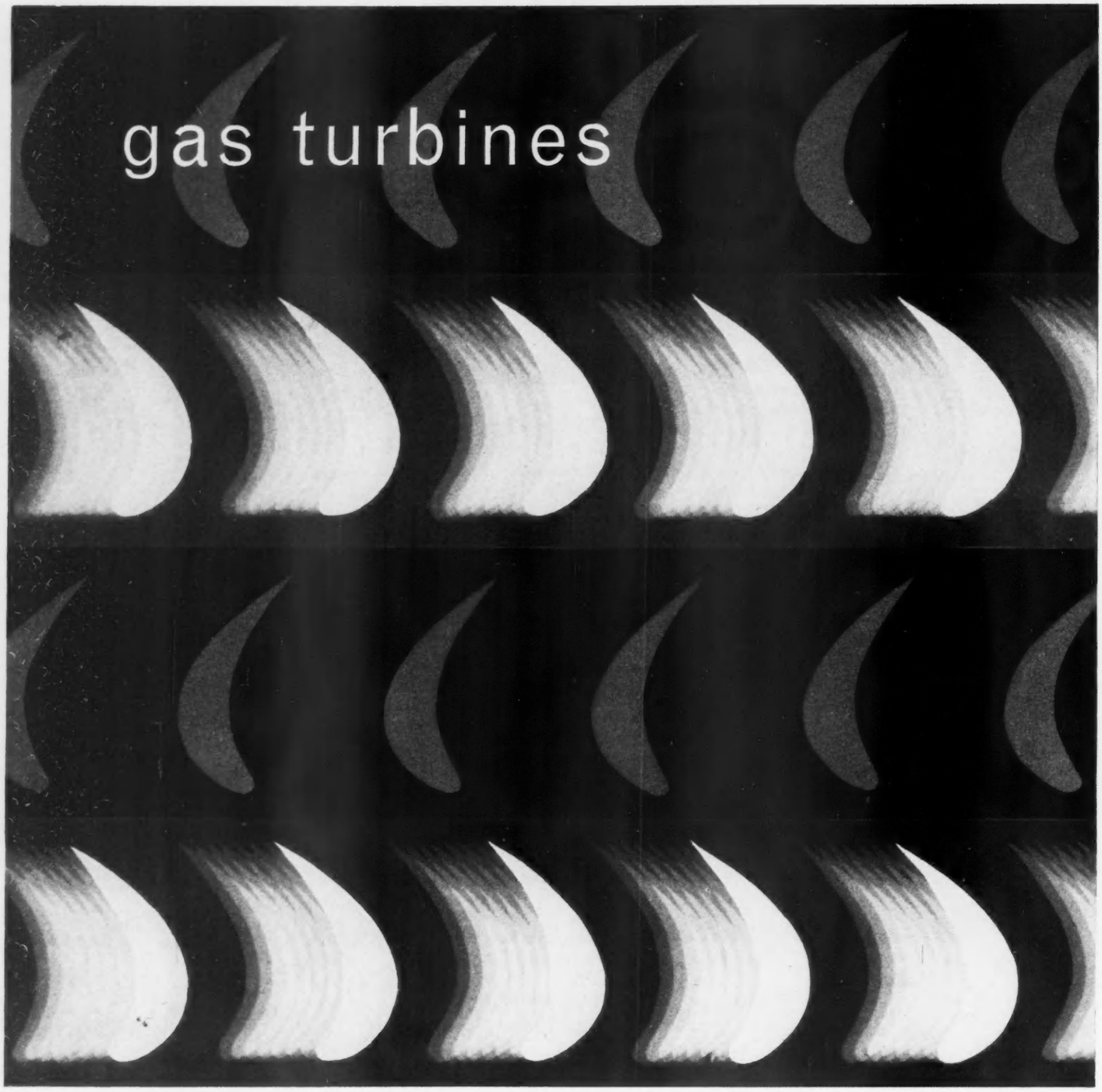

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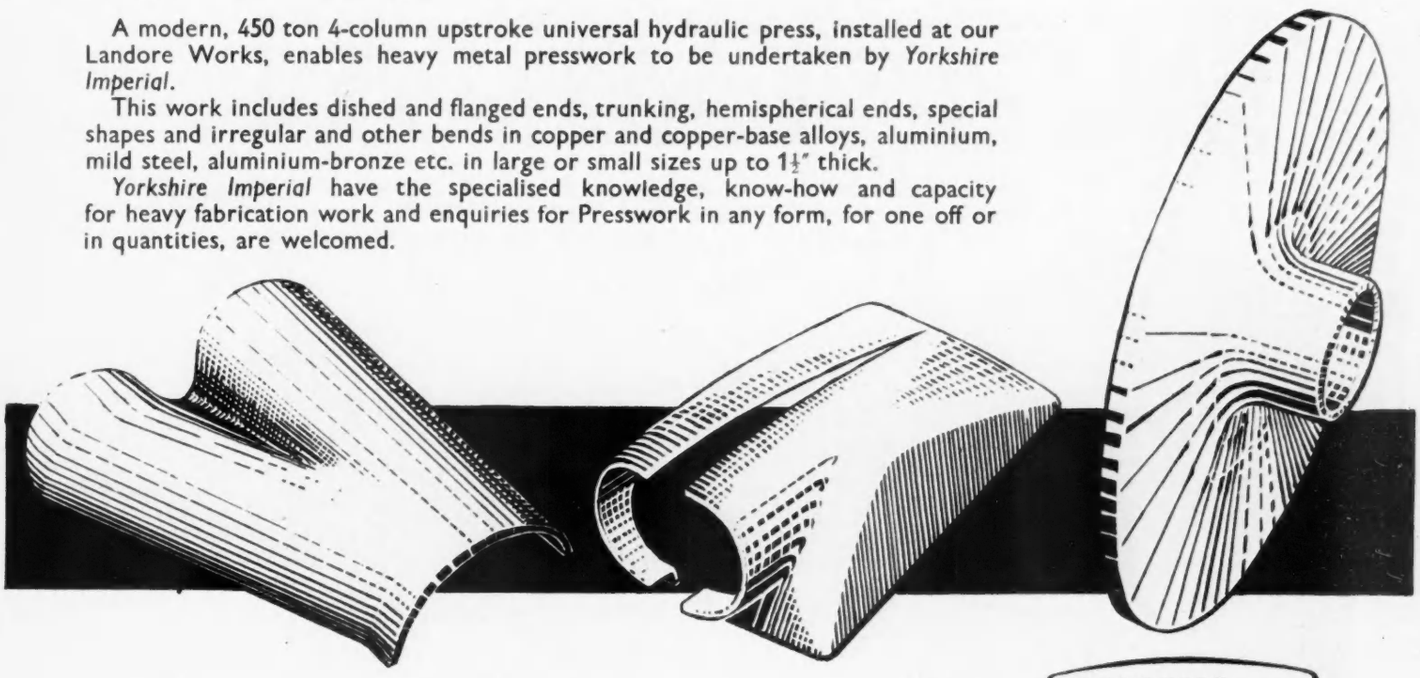

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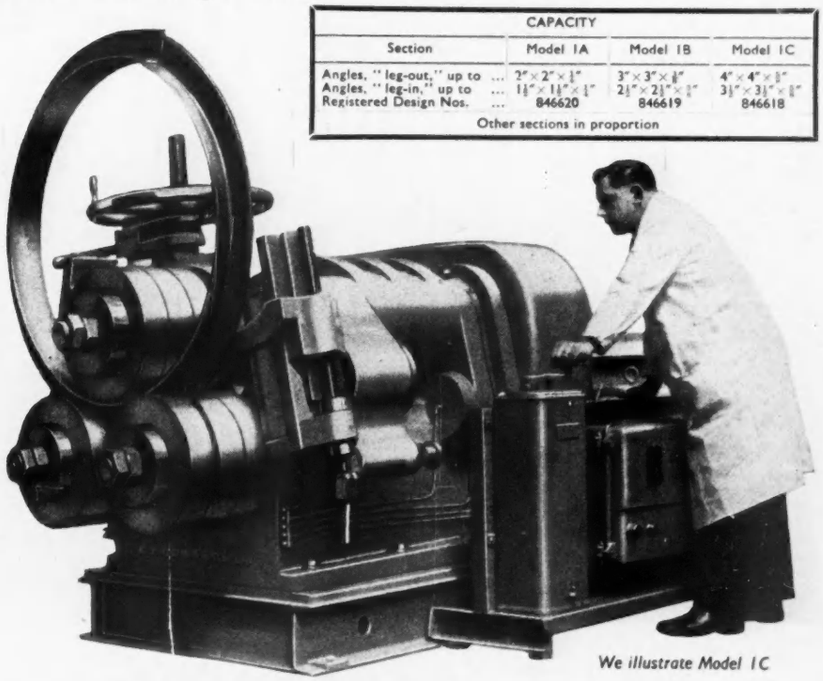

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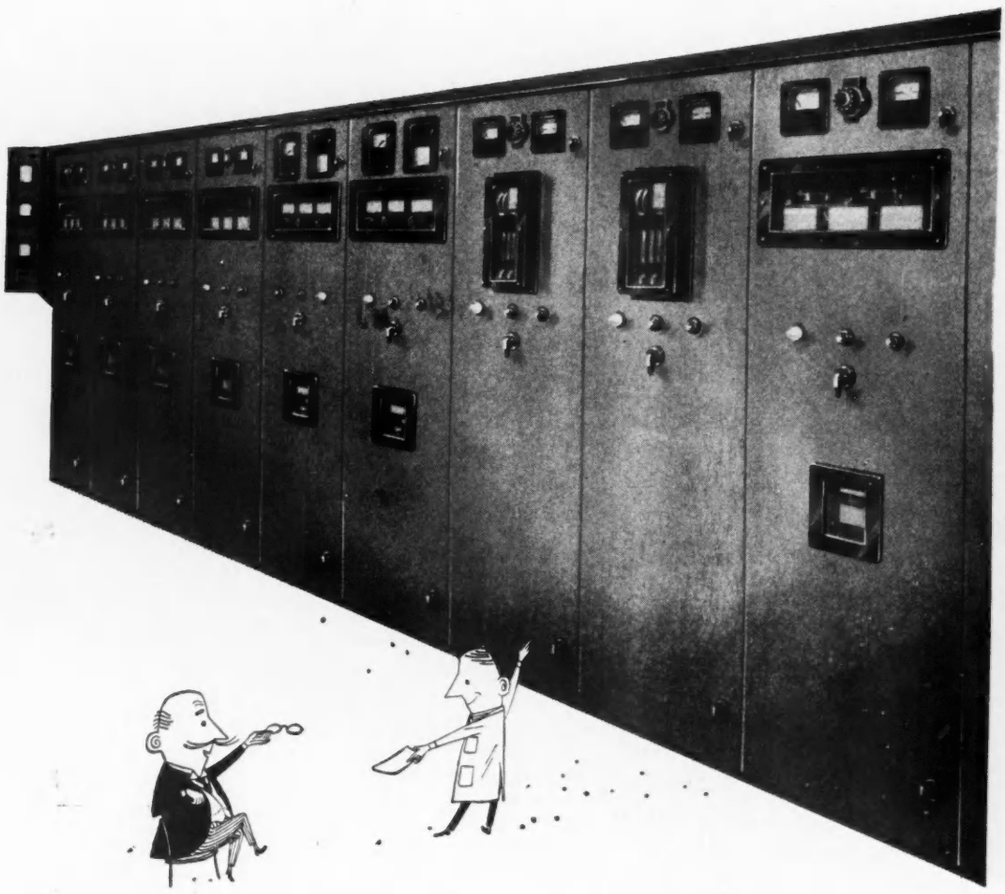

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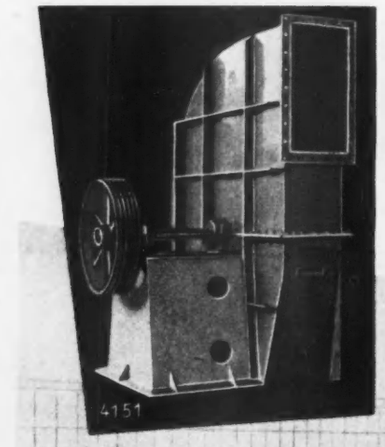

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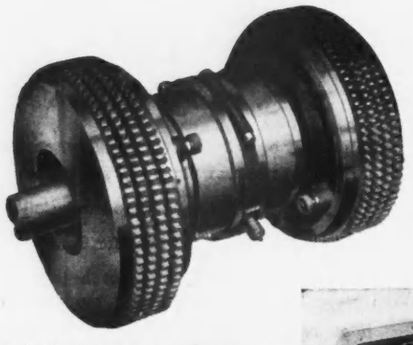

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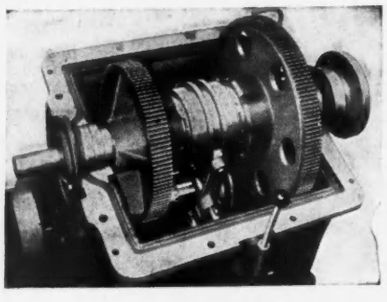

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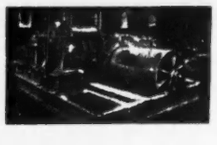

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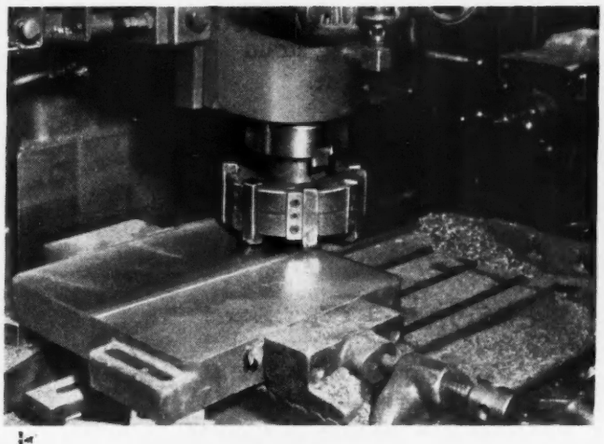

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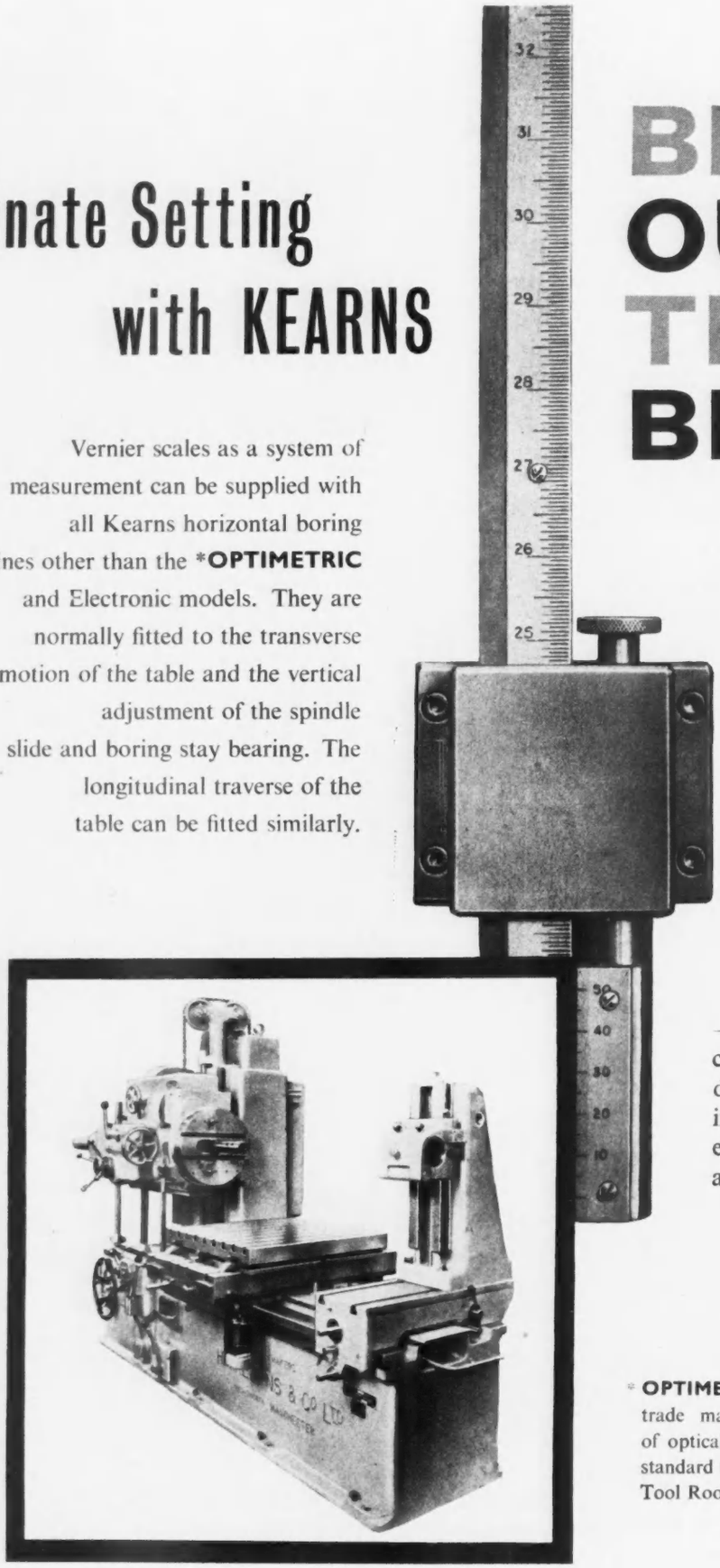

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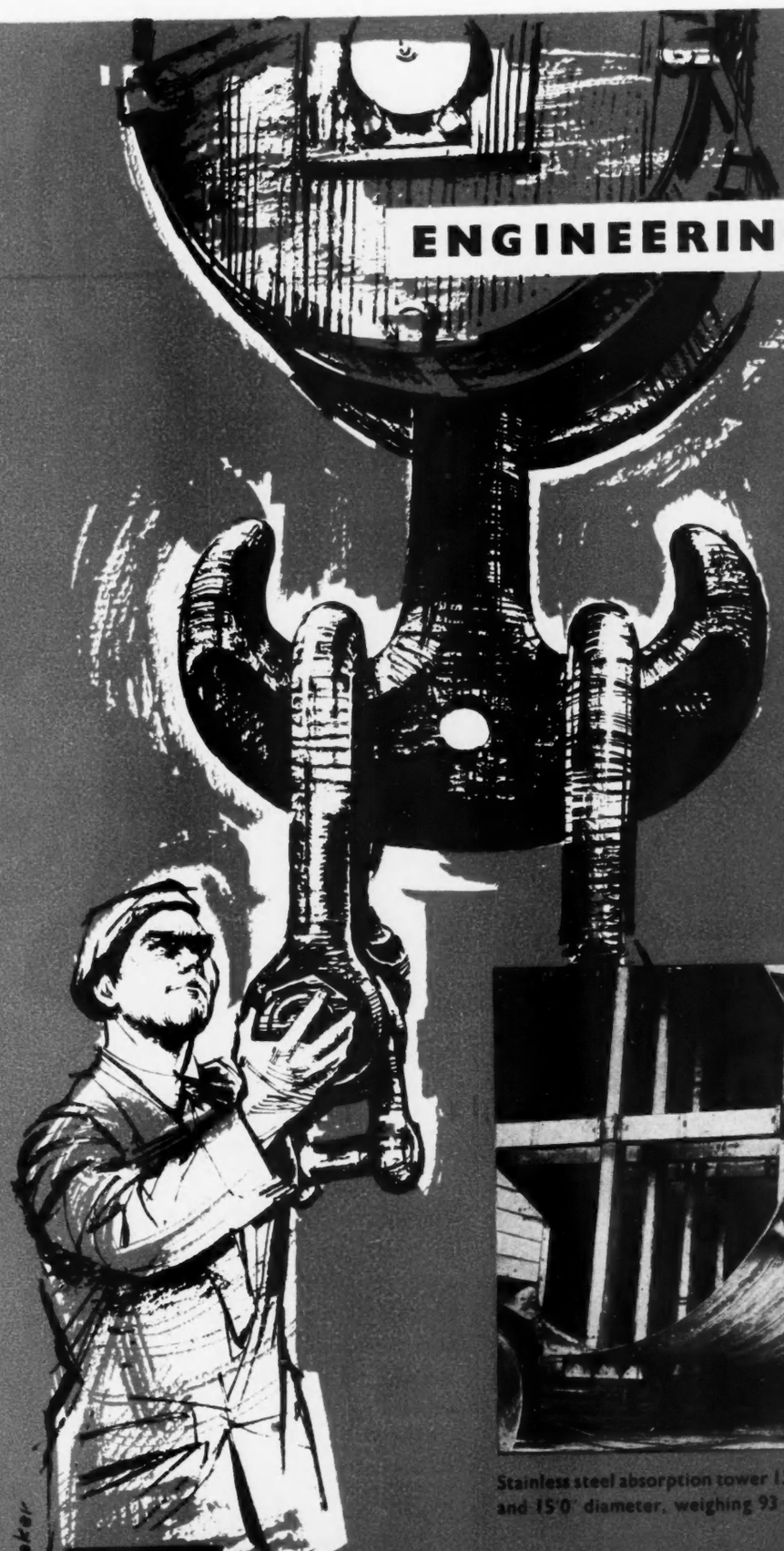

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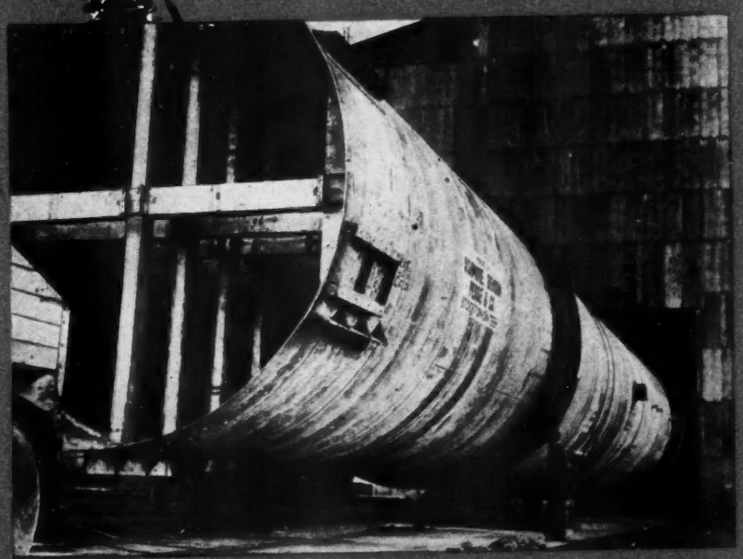

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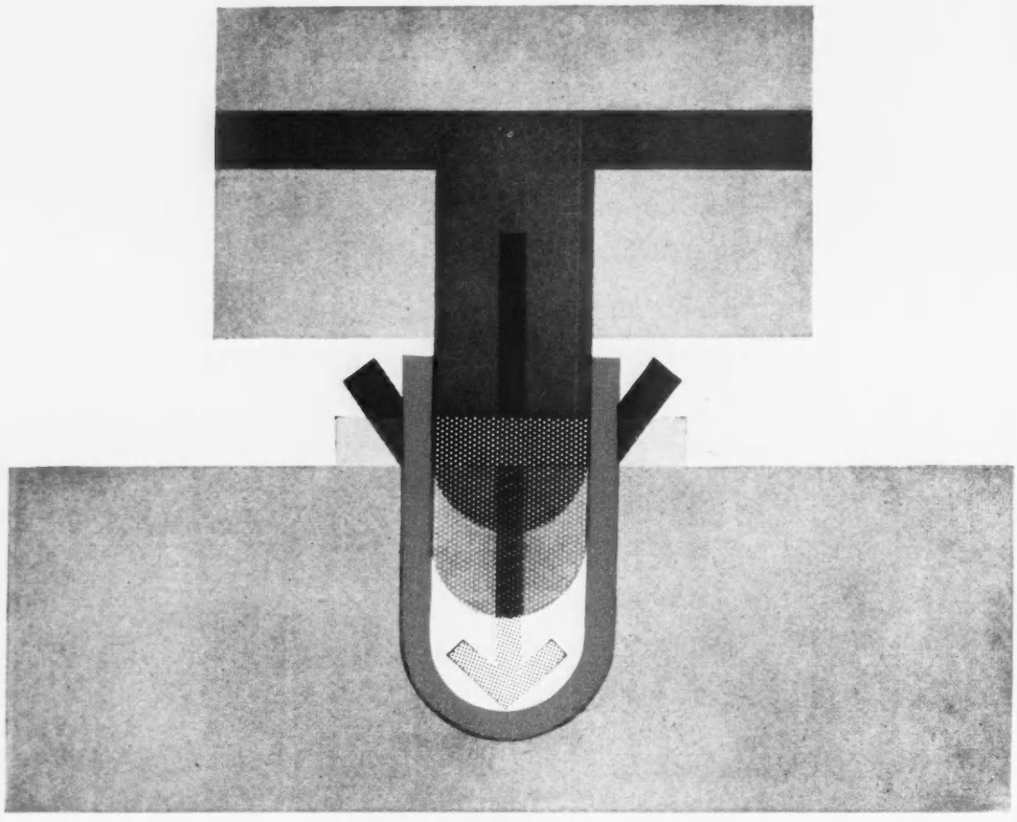

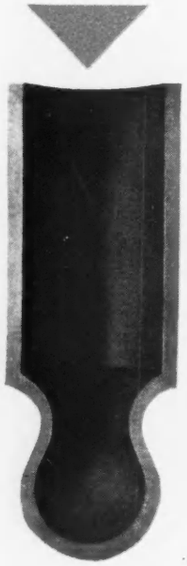

Wilmot Breeden have recently developed a method of cold working (drawing and rolling) shells to close tolerances and high surface finishes. Applied to the quantity production of precision components, formerly machined from bar or forgings, it provides striking economies and high output rates.

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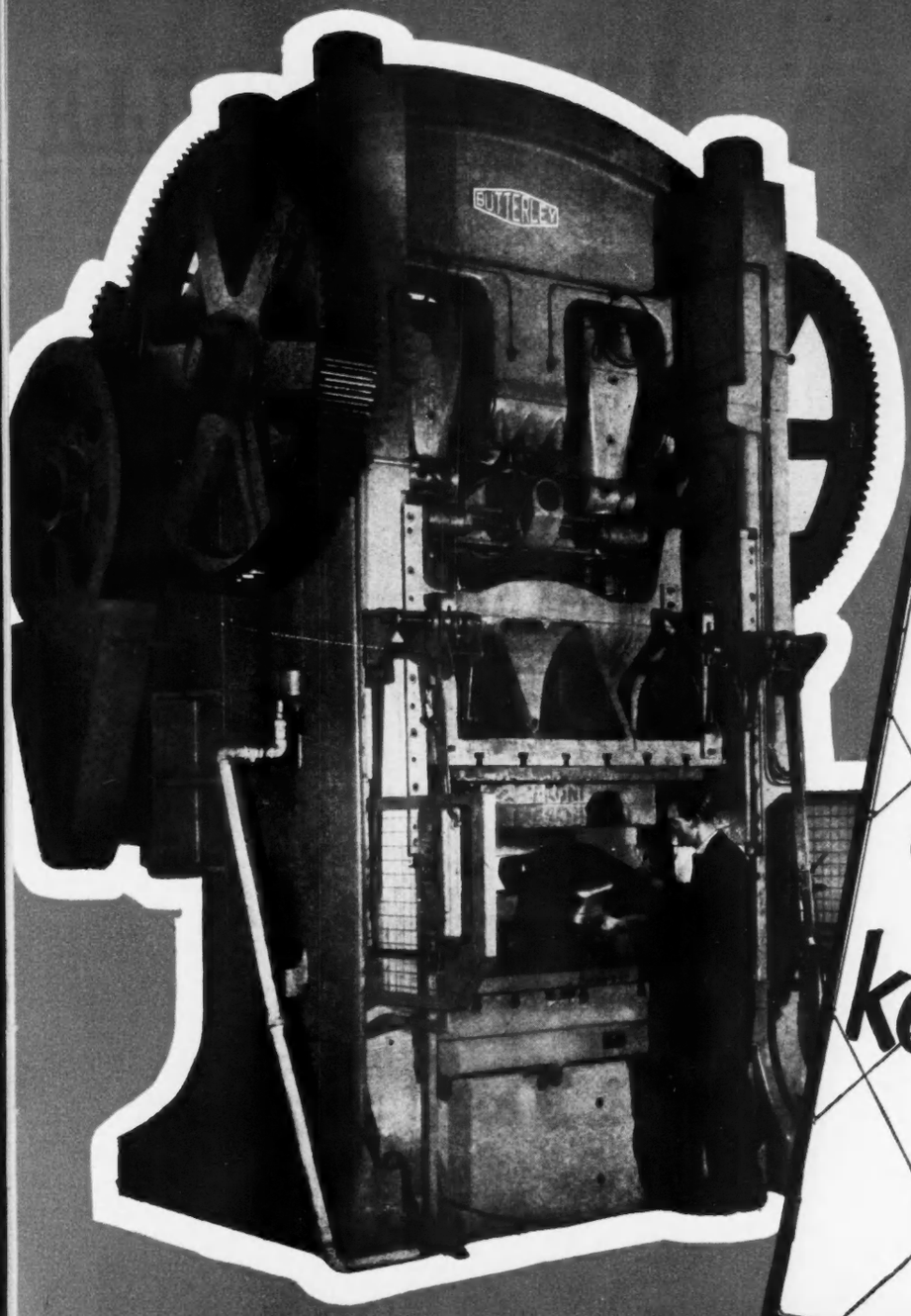

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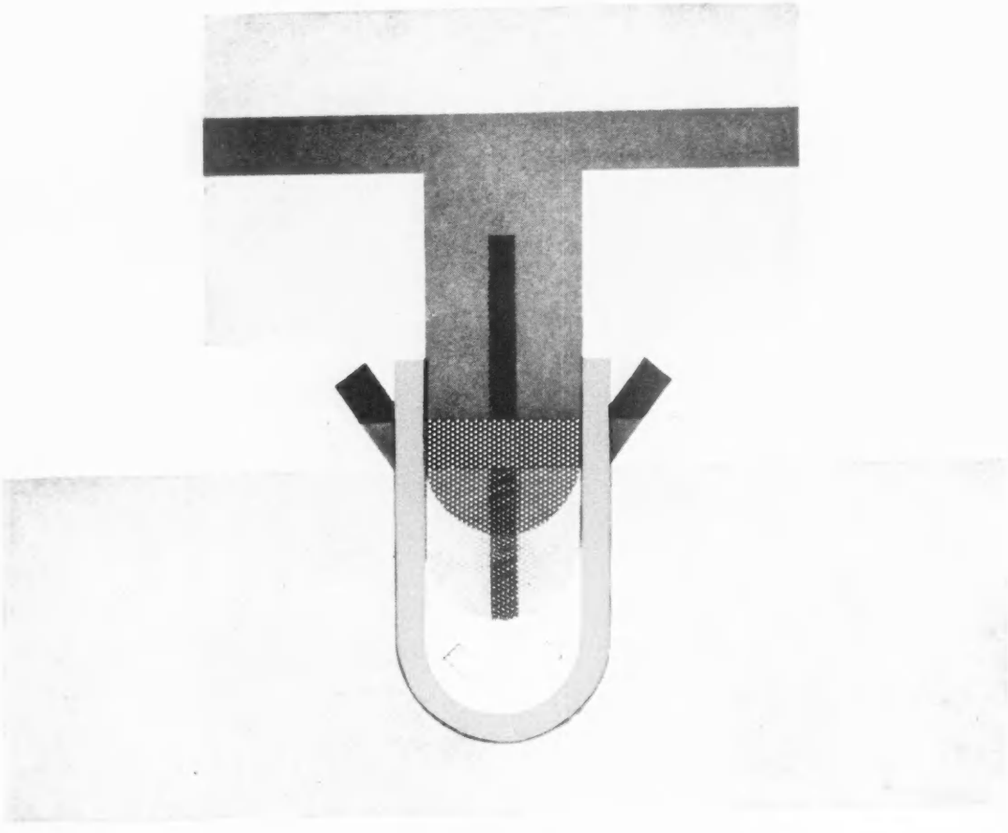

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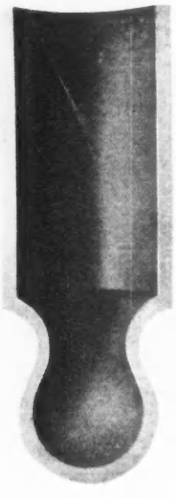

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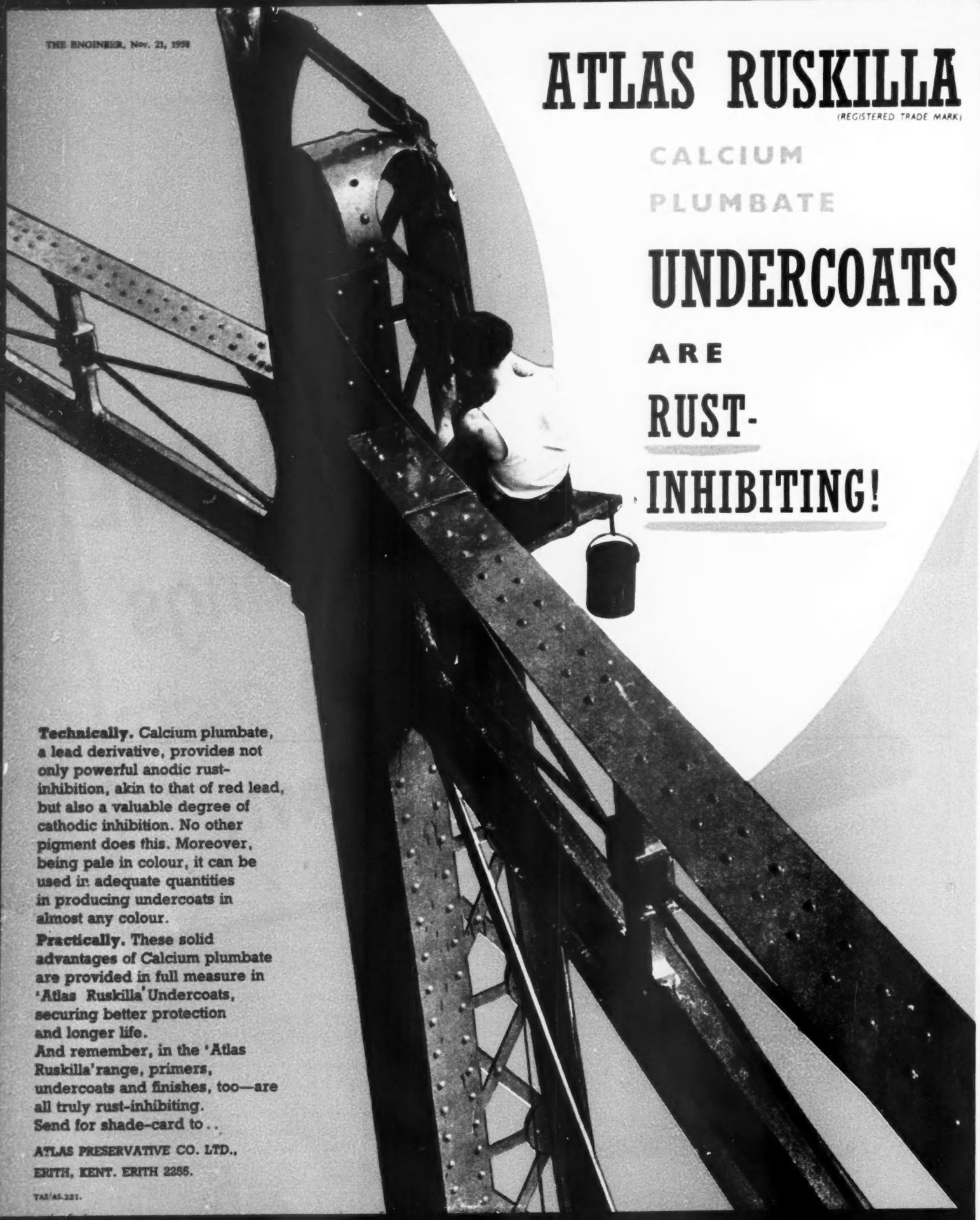

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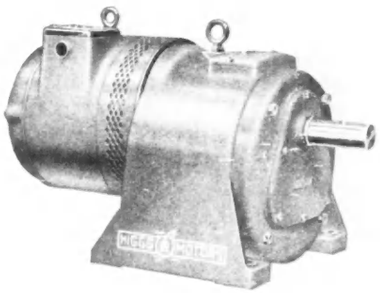

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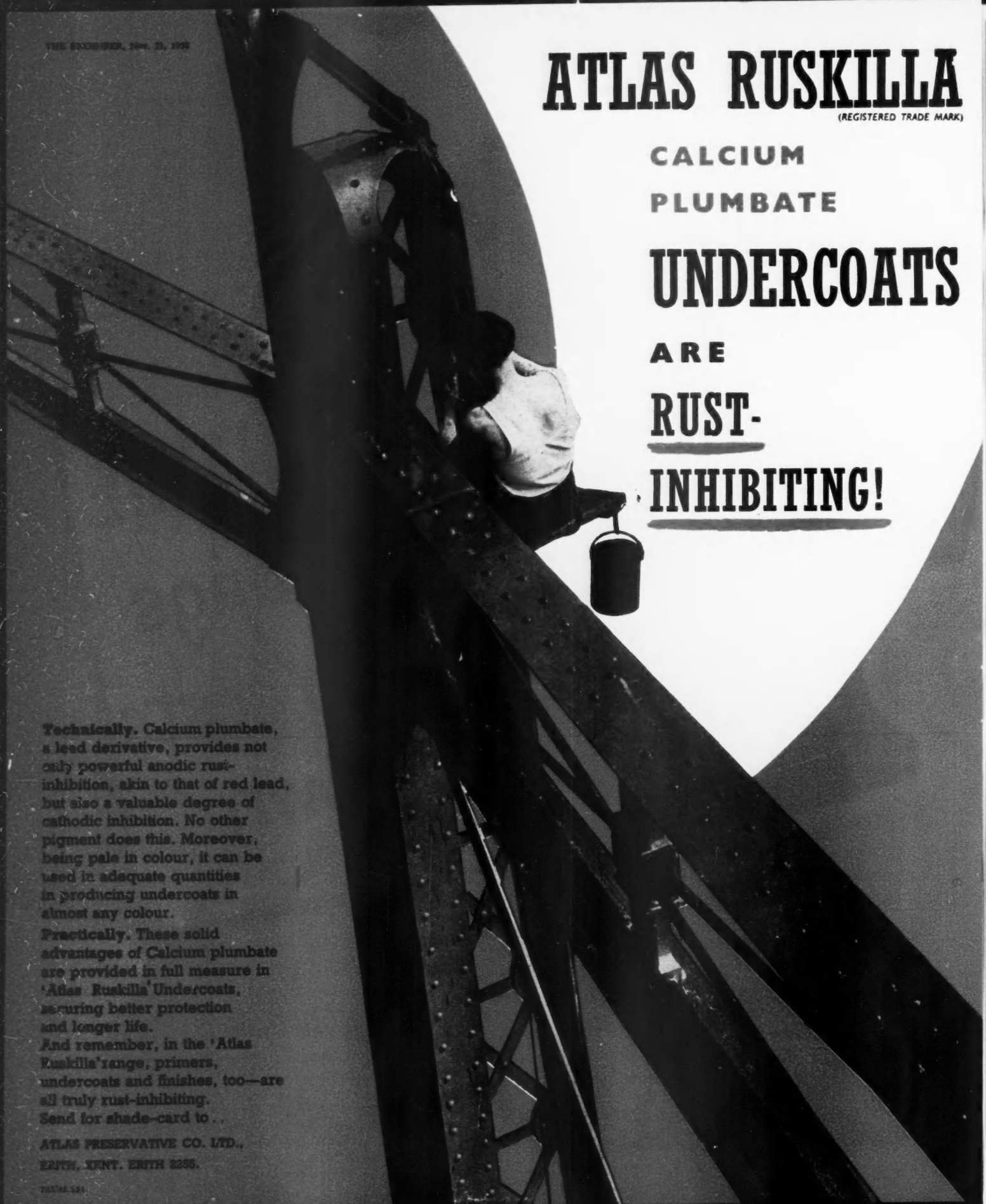

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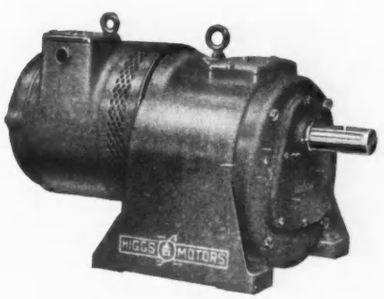

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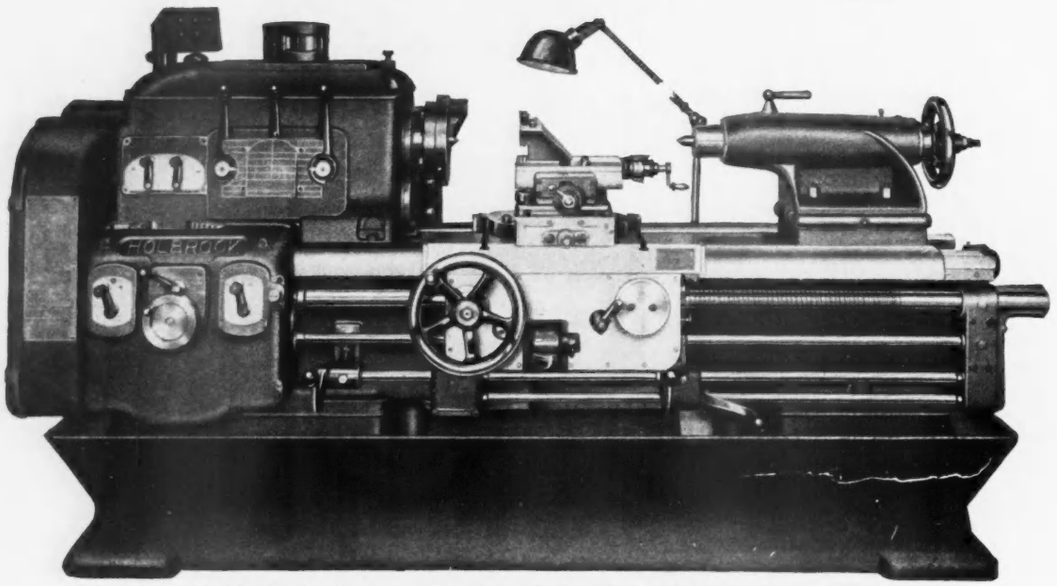

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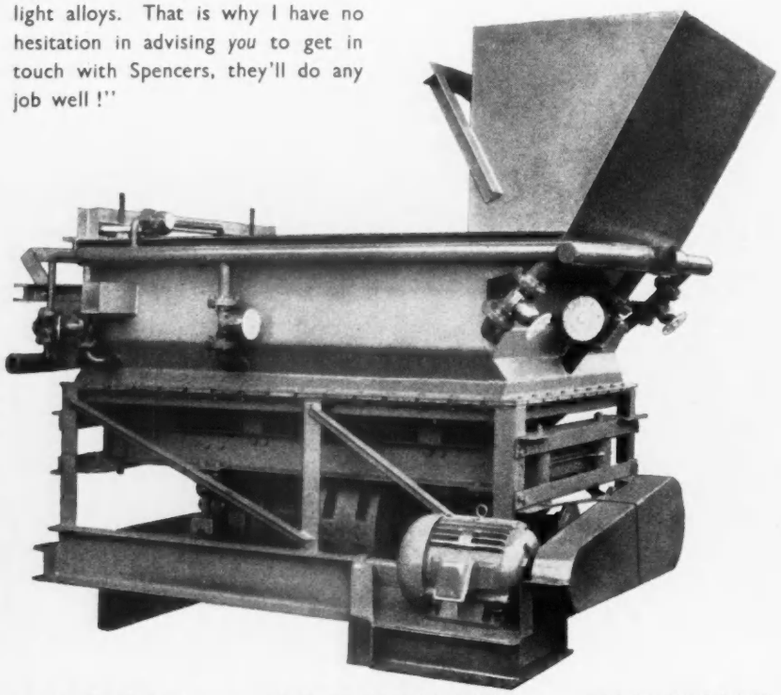

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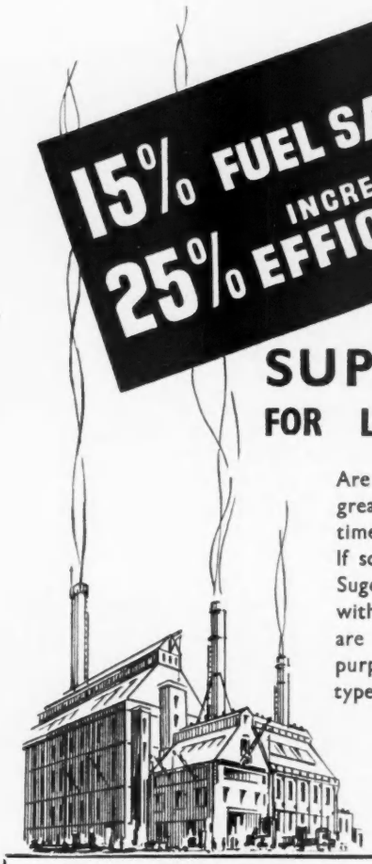

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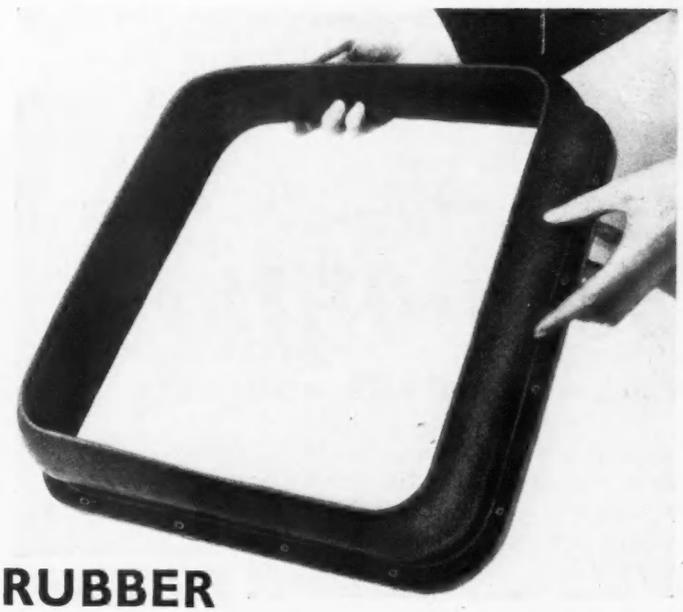

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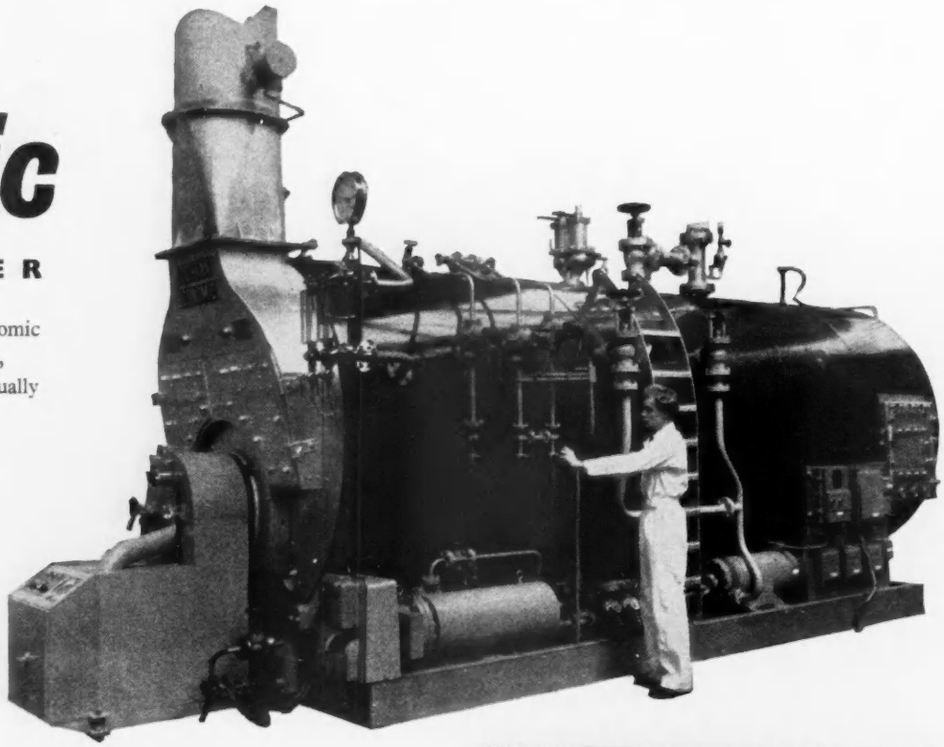

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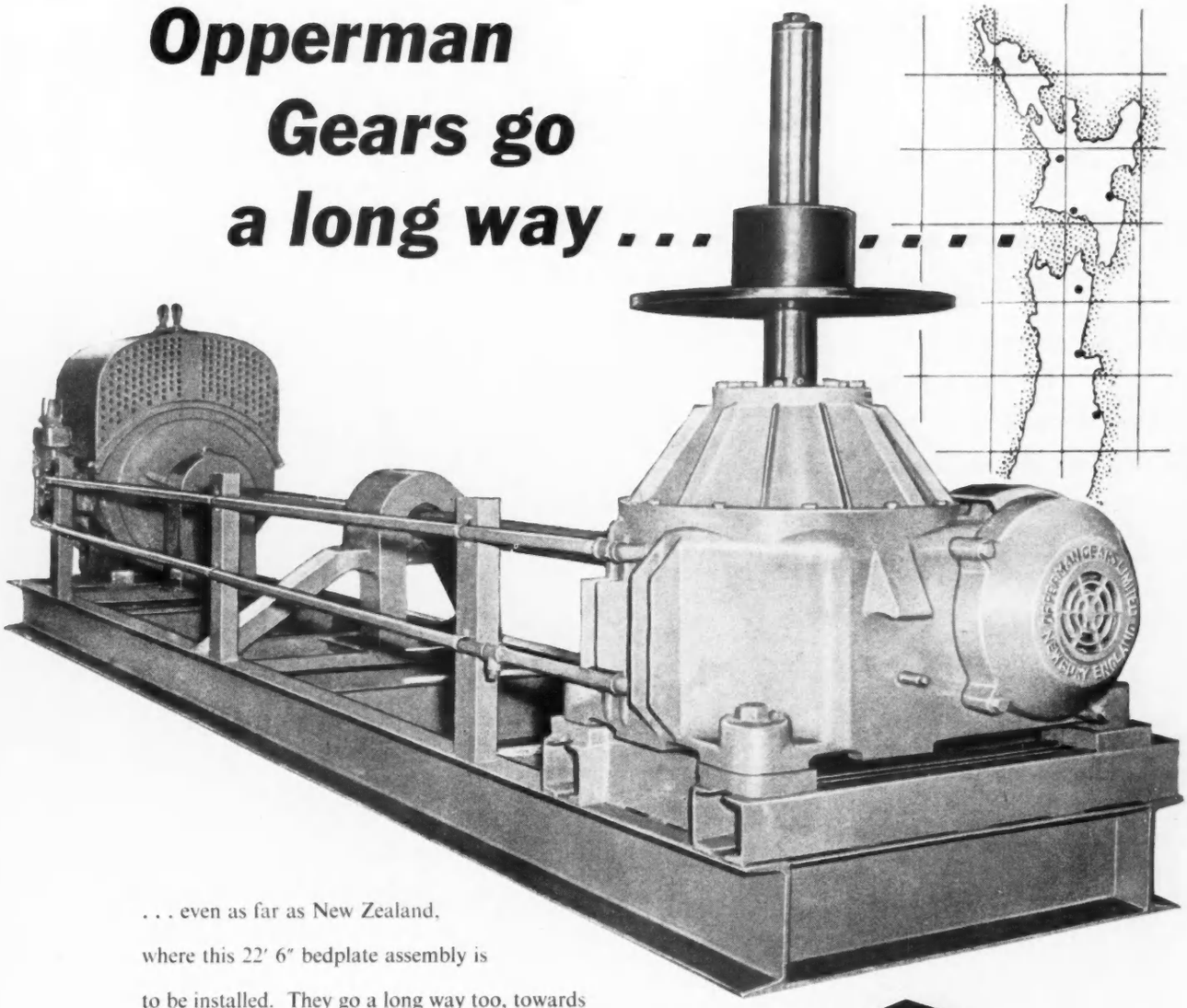

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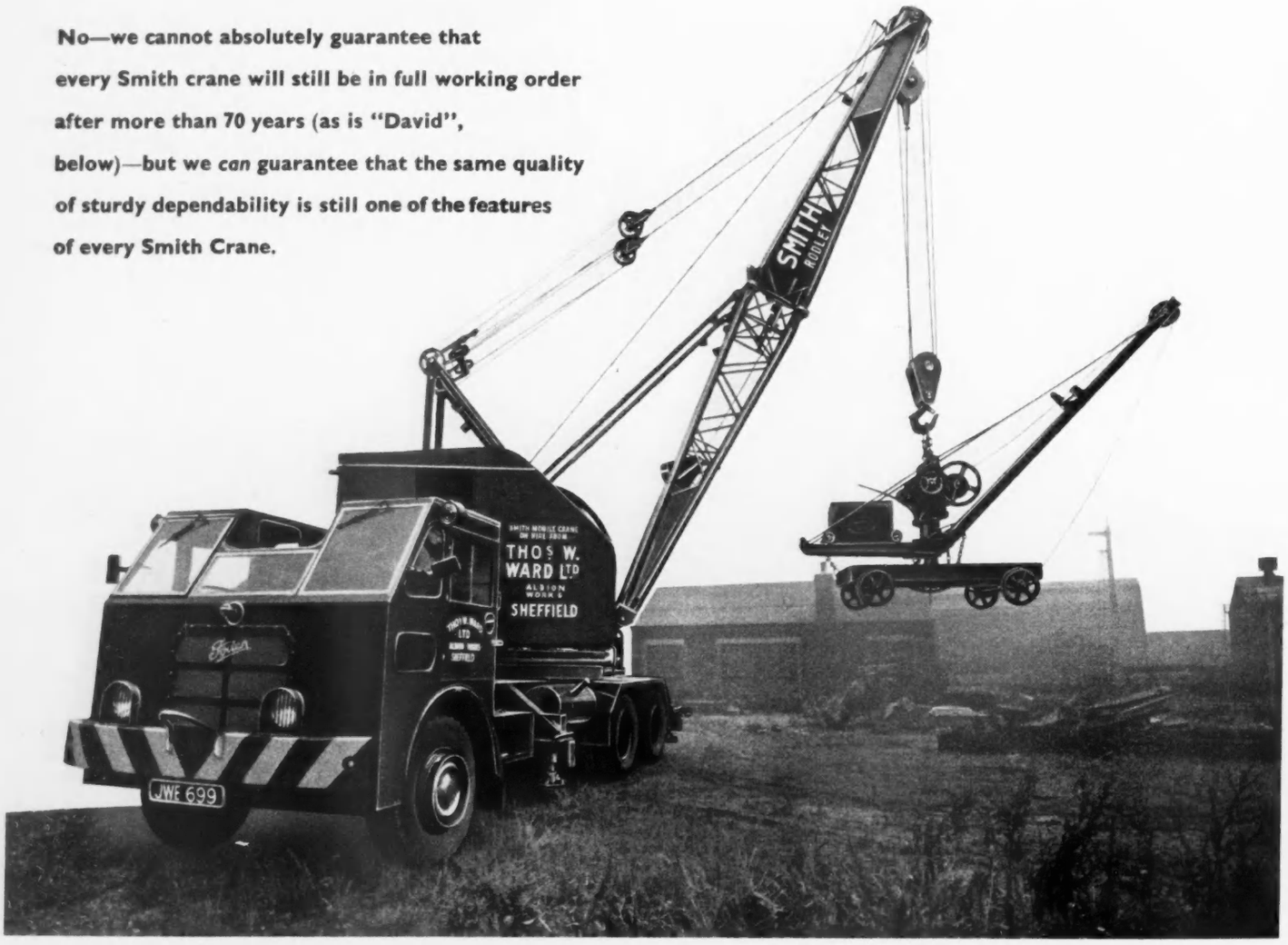

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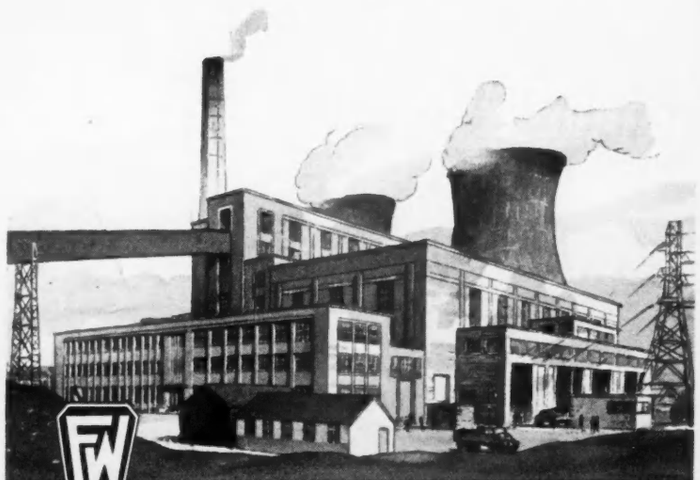

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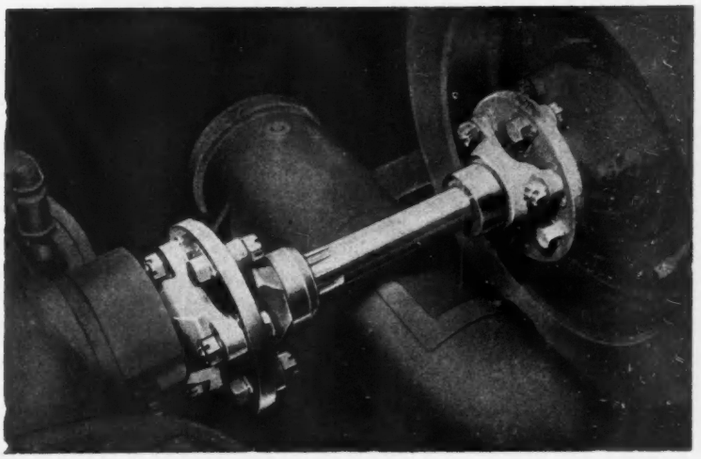

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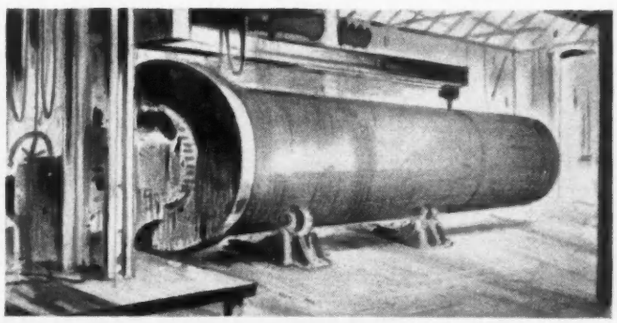

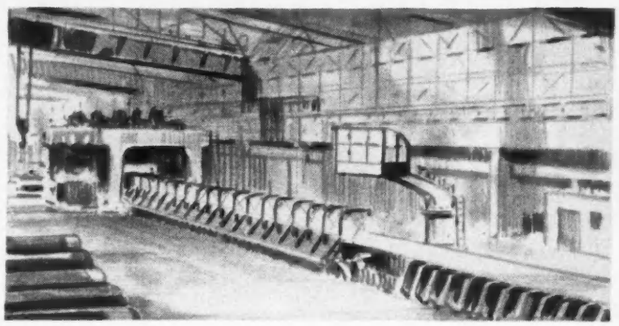

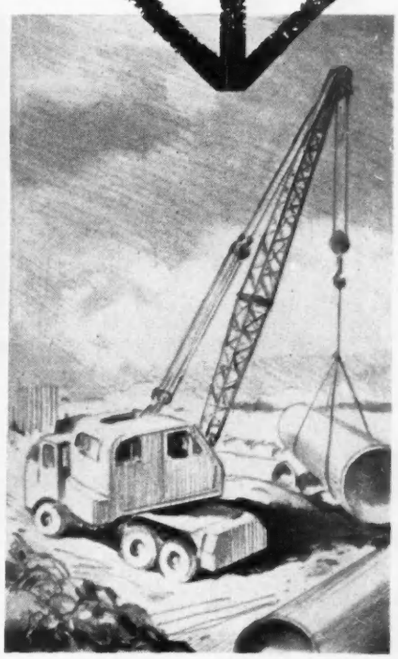

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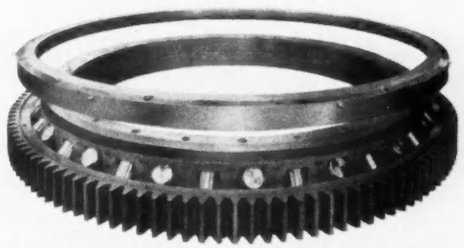

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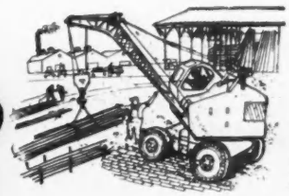

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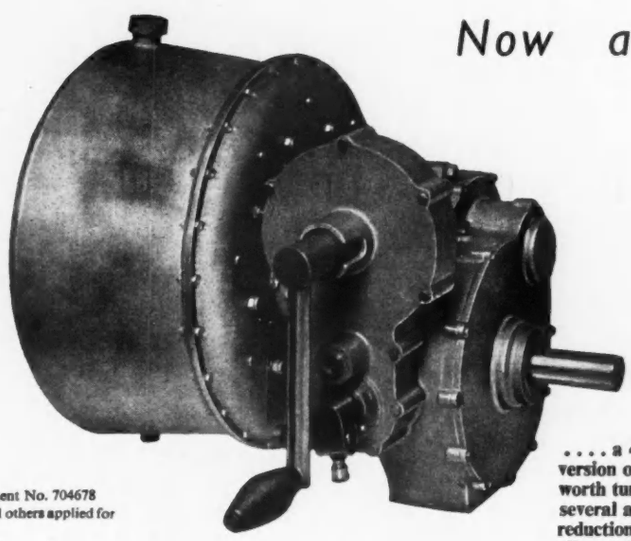

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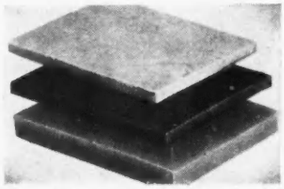

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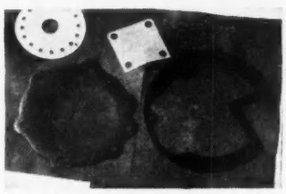

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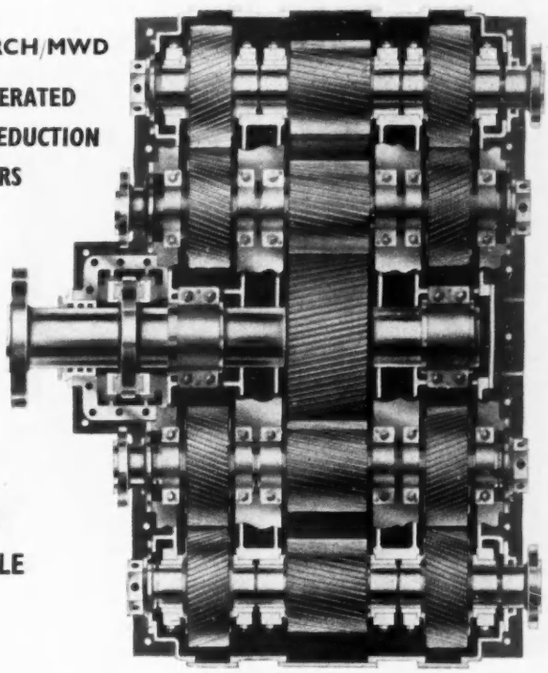
FOR USE WITH SINGLE TWIN OR QUADRUPLE ENGINES OR TURBINES



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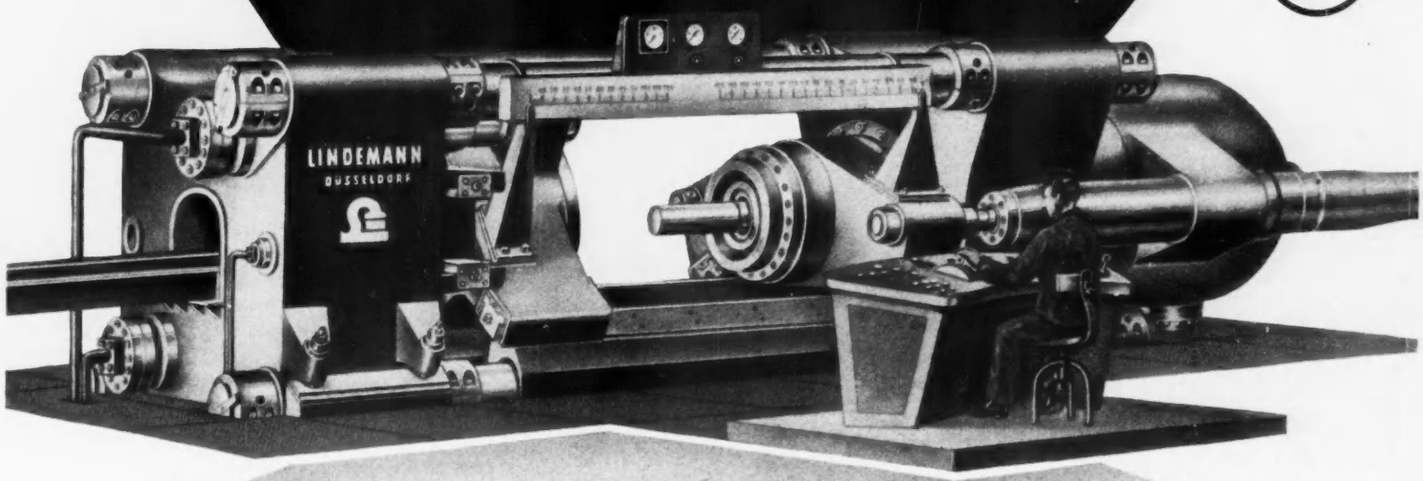

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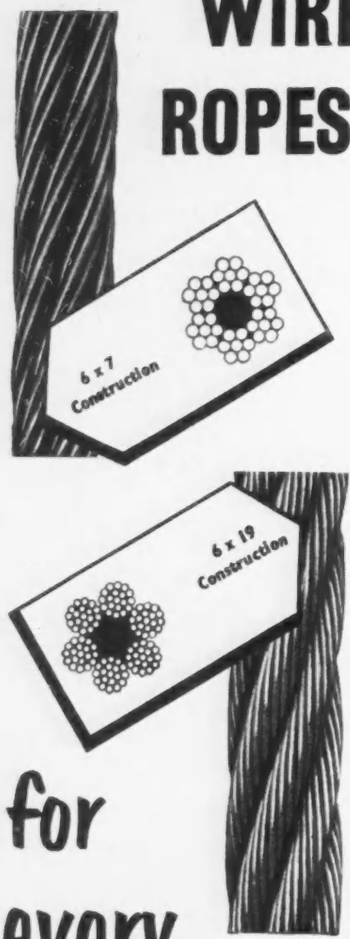
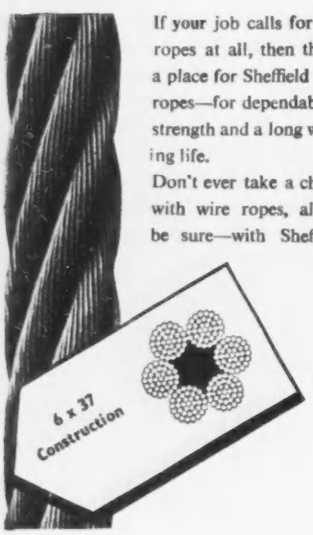


for every purpose



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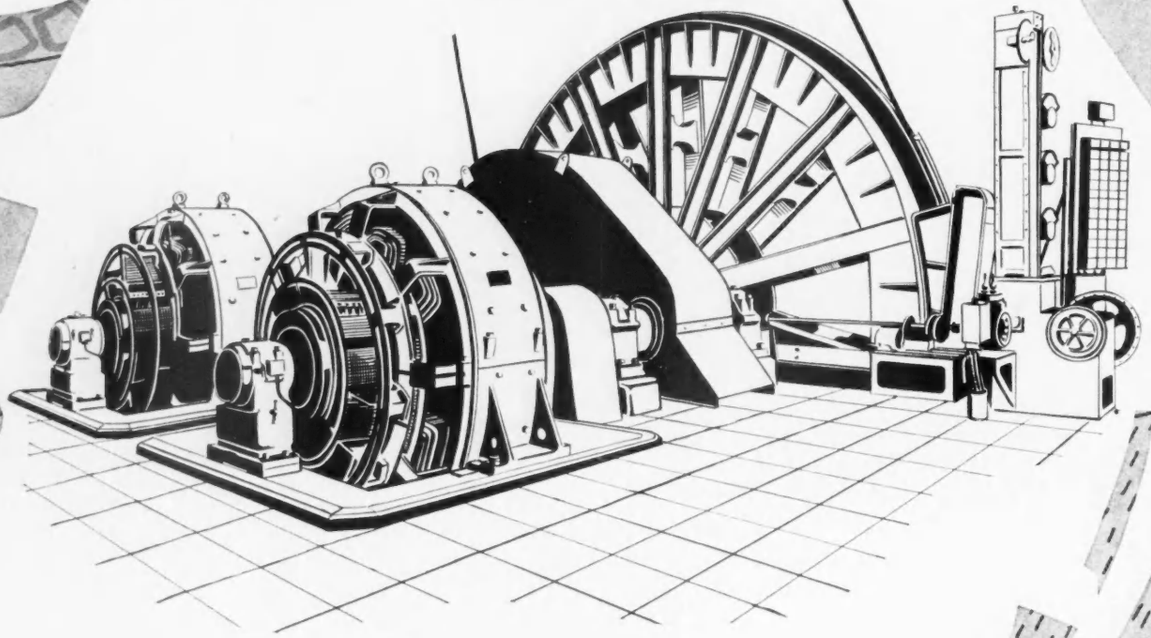

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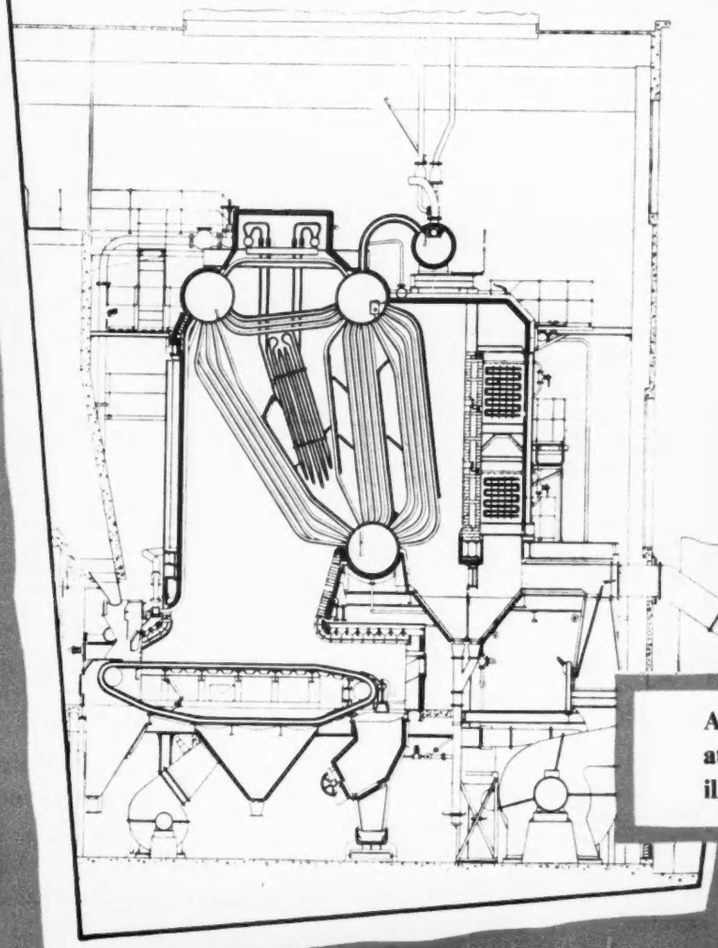

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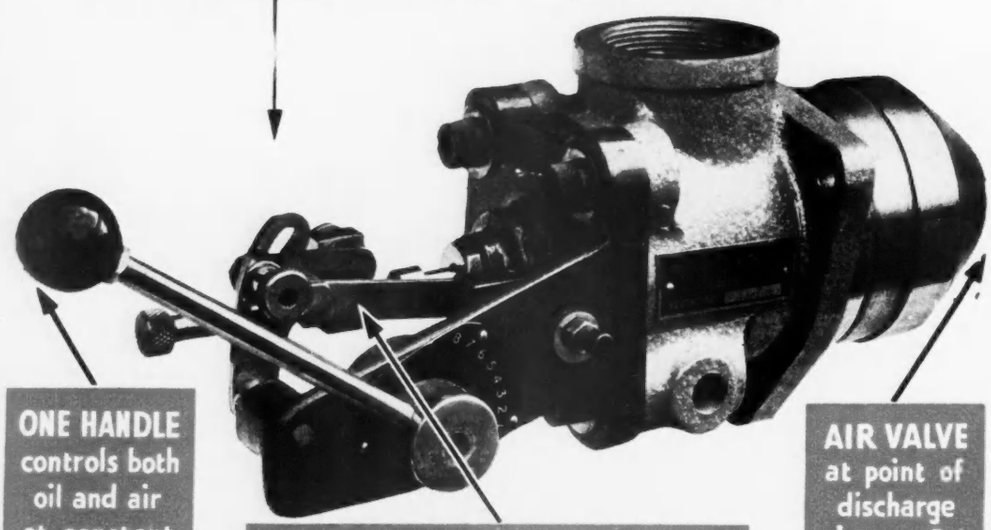

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NOW made with OIL VALVE STROKE infinitely variable by two adjustments only

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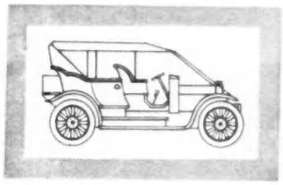

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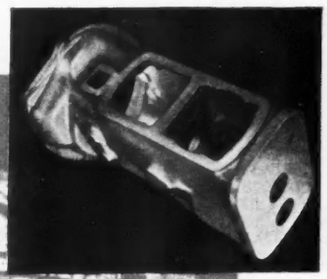

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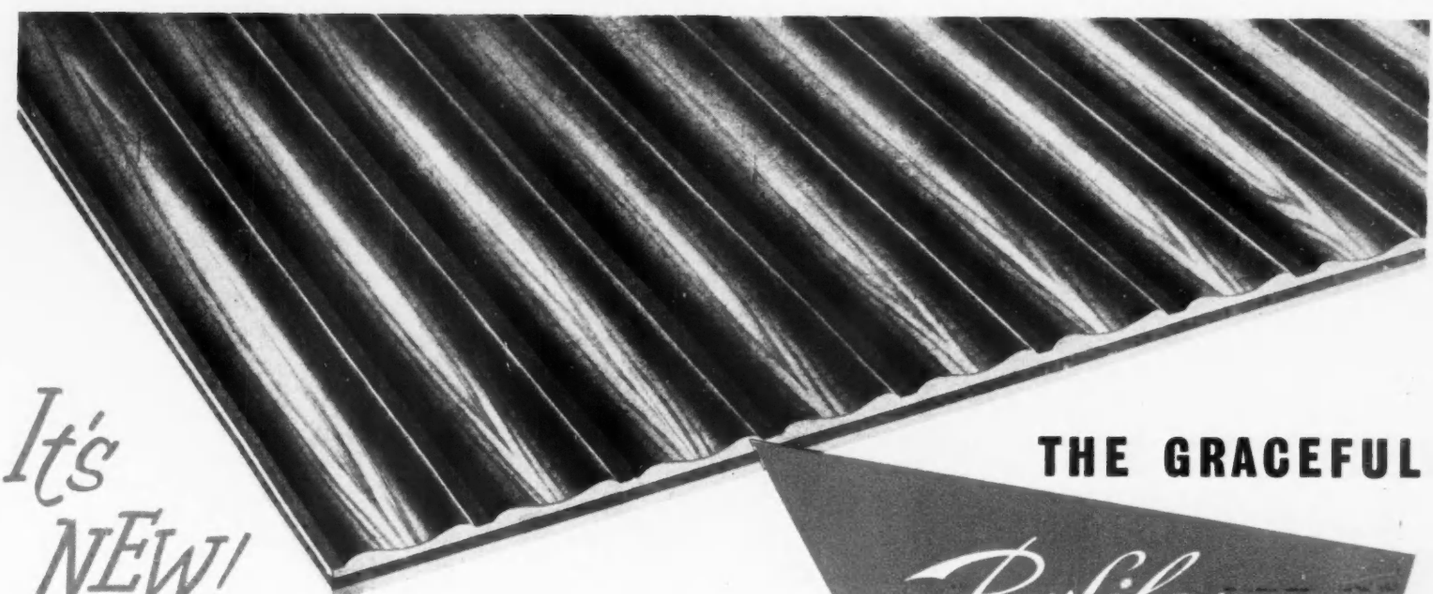
used in Sir Edmund Hillary's Antarctic Expedition.
By courtesy of Massey-Harris-Ferguson Ltd.



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The PROFILCO panelling is a Plywood made from three layers of 2.5mm. Utile Mahogany veneers. Bonding A-70 and AX-100. The face veneer has a most attractive profiling and the edges of the boards have been moulded in such a way that, when joined together, the joints cannot be noticed.

The PROFILCO boards are carefully sorted in order to attain a uniform appearance.

A natural oil finish or cellulose lacquer finish is recommended.

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A-70 Bonding
5′ × 2′ 6′ × 2′
7′ × 2′ 8′ × 2′

AX-100 Bonding 8′ × 2′

Packed 15 boards to a bundle.

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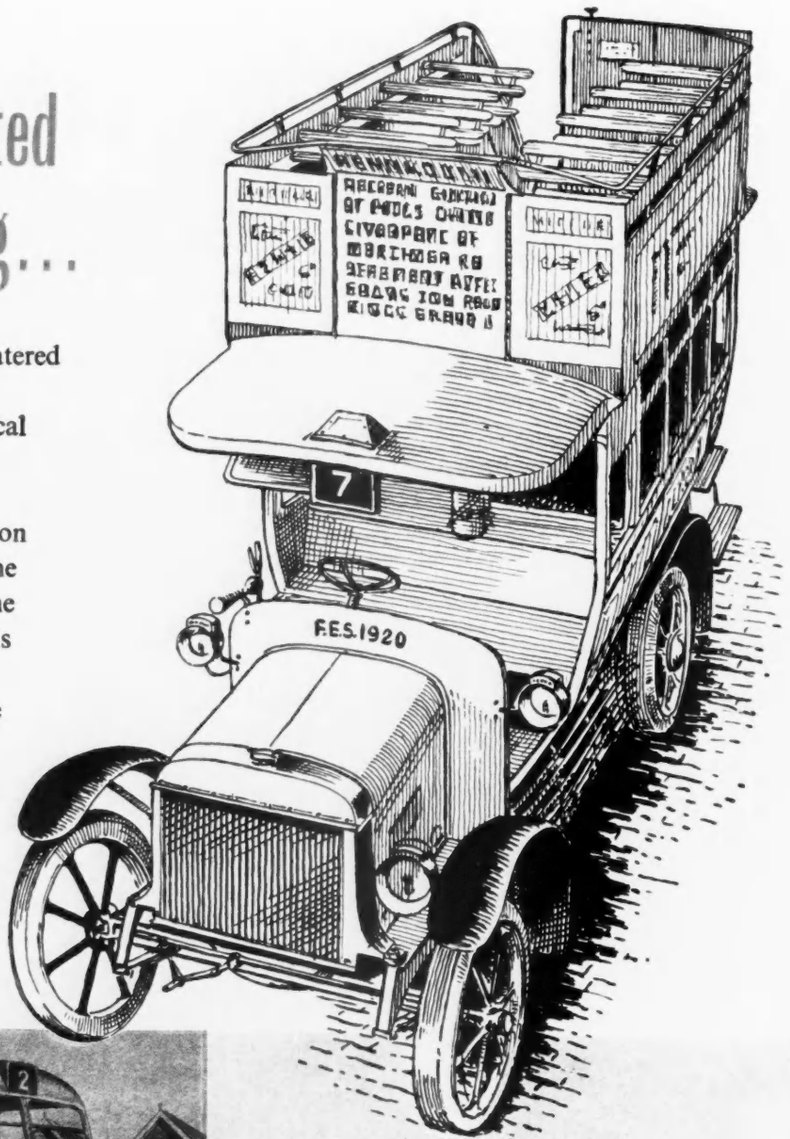

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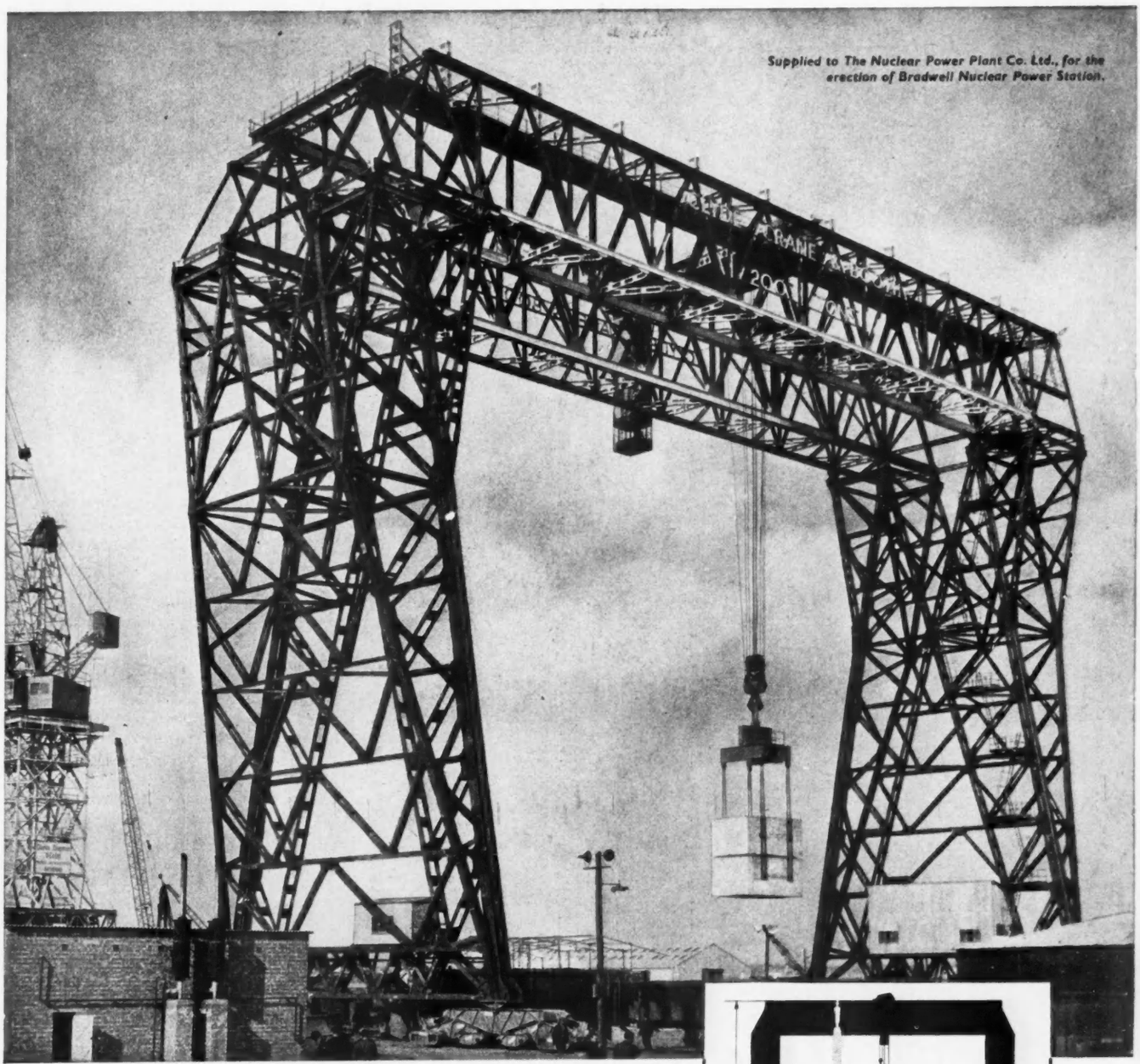
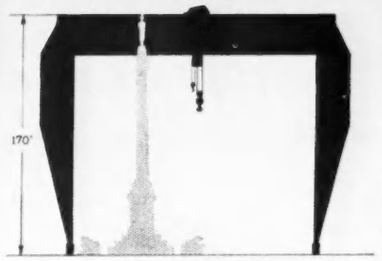
YGA 148

CLYDE-BOOTH 200 TONS GOLIATH AT *BRADWELL NUCLEAR POWER STATION*



Supplied to The Nuclear Power Plant Co. Ltd., for the erection of Bradwell Nuclear Power Station.

Specially designed for the erection of Bradwell Nuclear Power Station this 200/30 tons Goliath crane handles all the major lifting operations on the main part of the plant. It completely spans the reactor buildings site travelling on rail tracks on either side so that large items of equipment such as boiler shells which weigh up to the crane's full capacity are easily lifted and placed with precision in the position required.



The Booth Goliath showing Nelsons Column on the same scale. Clearance from rail level to underside of bridge is 140'. Distance between rail centres 178'.

CLYDE BOOTH

CLYDE CRANE & BOOTH LIMITED

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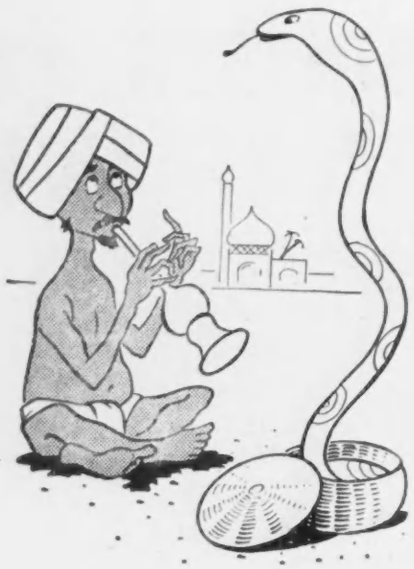

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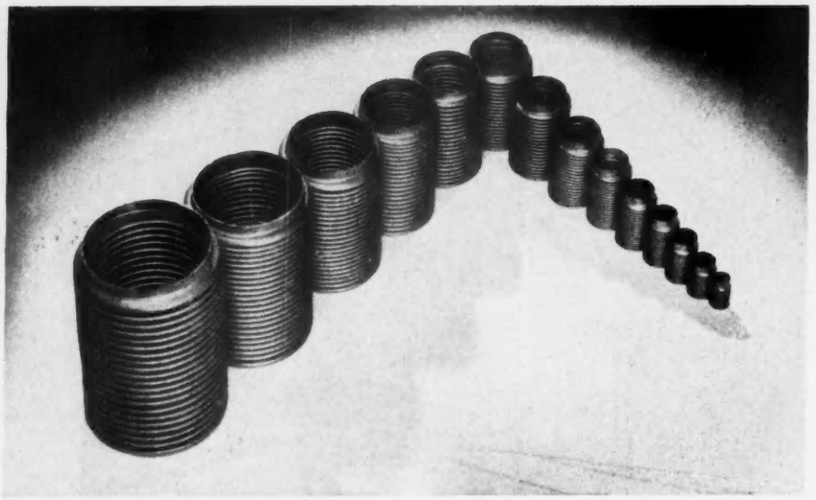

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Compact—Reliable—Economical—Efficient.

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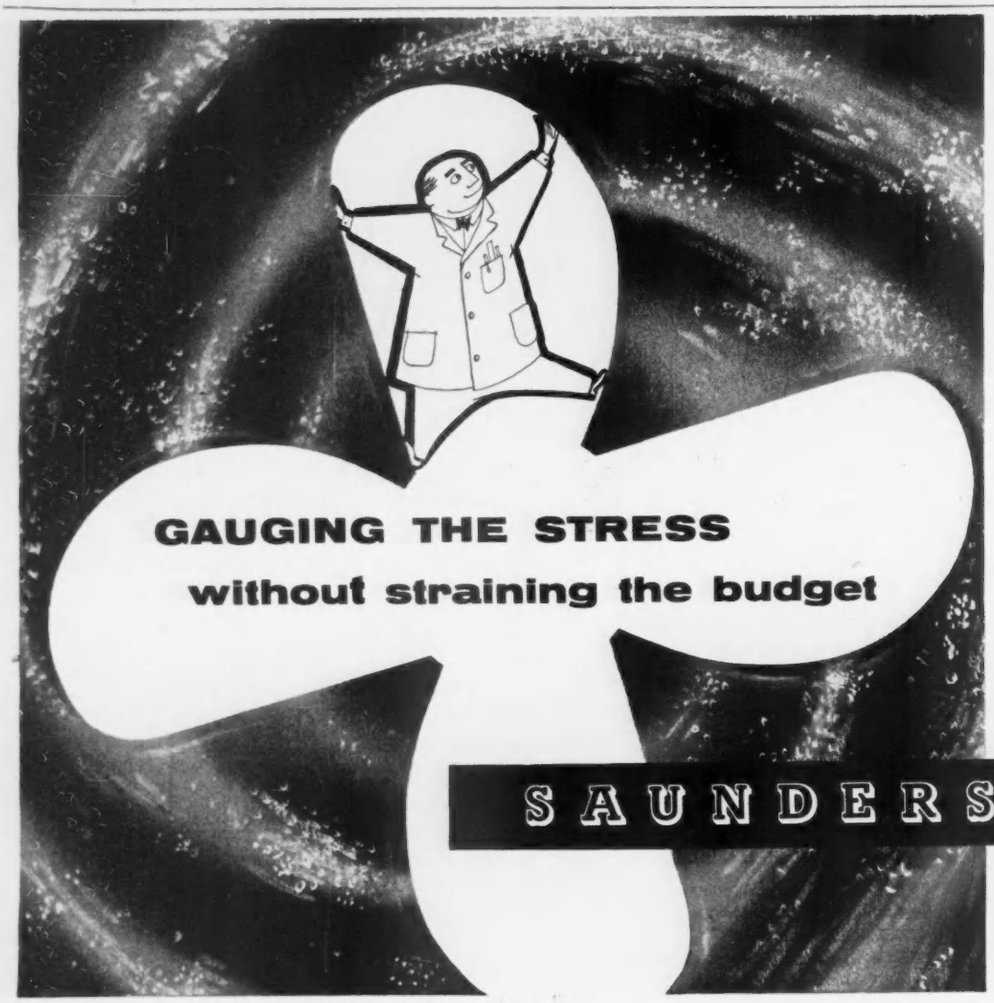

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Saunders-Roe Foil Strain Gauges find the facts precisely about any kind of mechanical stress or strain—moving or static, large or small, normal or abnormal. They are inexpensive and simple to install. New applications in which they give essential and often unique service are constantly being found.

For instance, Foil Strain gauges have:

- *measured for the Admiralty the stresses in the propellers of sea-going ships.*
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- *located for the Timber Development Association the transient high bending stresses of wood and plastic archery bows.*

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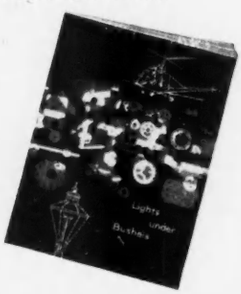

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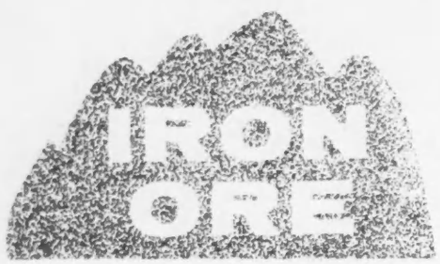
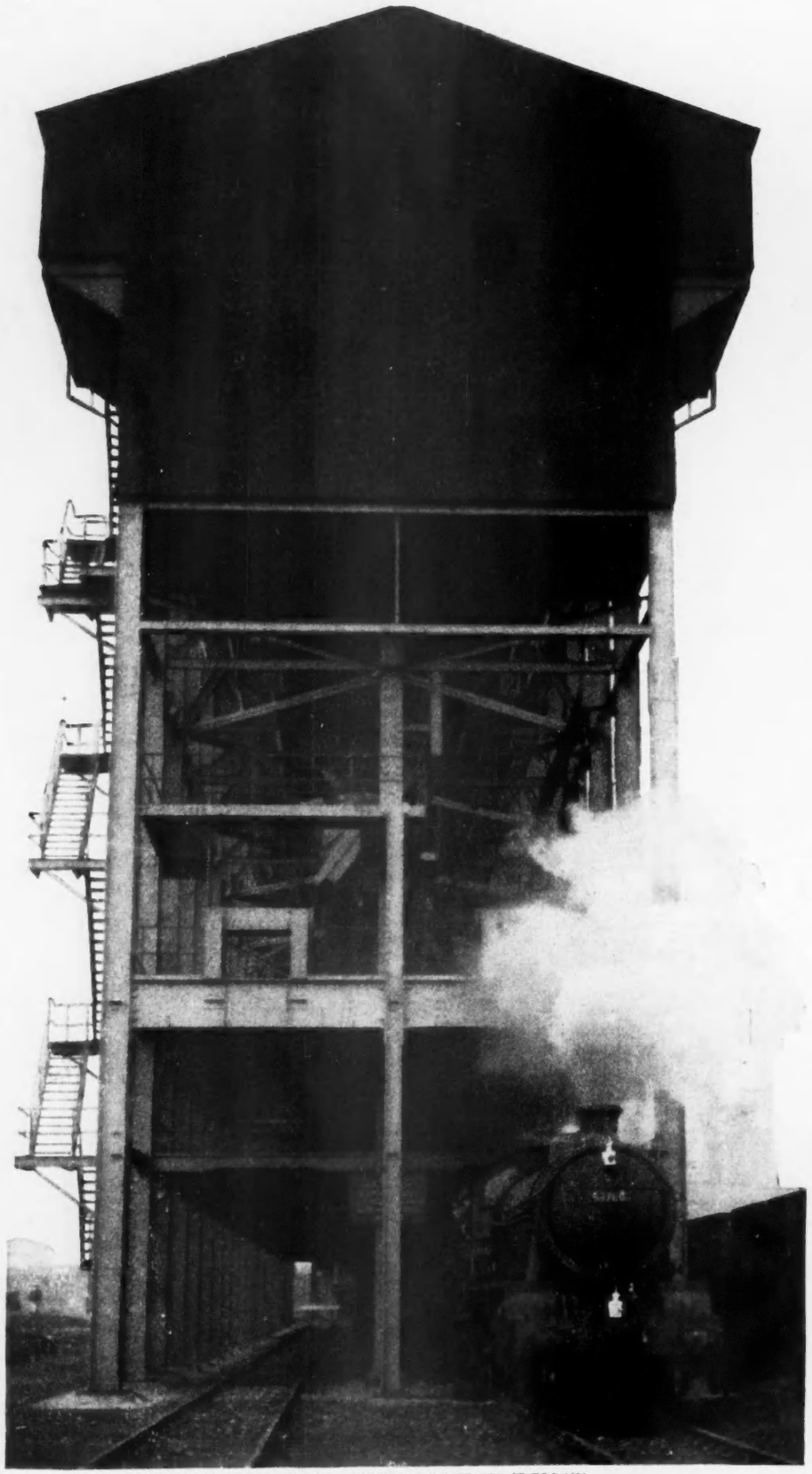


Another train carrying 500 tons of ore leaves Tyne Dock, South Shields, for the blast furnaces. The ore has been handled in a Simon plant that moves it at a maximum rate of 1500 tons an hour from ship to shore. From Simon storage bunkers with a maximum capacity of 12,700 tons, the ore is weighed out into two lines of loading out hoppers. A train draws under one of the lines and over 500 tons of ore are released in a few seconds to waiting wagons. Every operation is carefully synchronised and controlled. In the three years after its commissioning in December 1953 this plant handled over three and a half million tons of ore. Plants designed and built by Simon are handling a wide variety of materials all over the world.



OUR BROCHURE "DISCHARGING IRON ORE AT TYNE DOCK" CONTAINS A FULL DESCRIPTION OF THIS PLANT. WHY NOT WRITE FOR IT TODAY?

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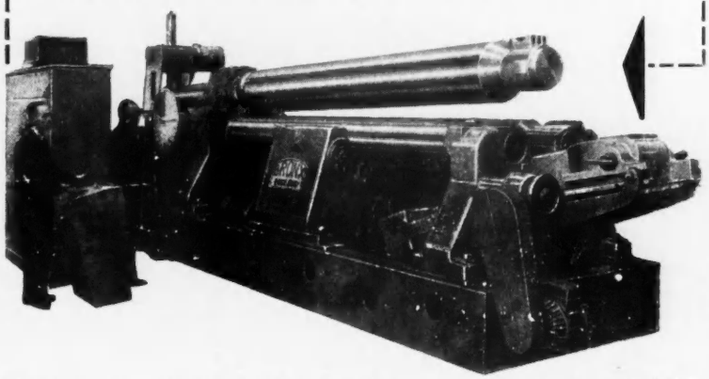

● Illustrated is a heavy-duty Bronx three-roll Pyramid Type Plate Bending Roll—complete with a desk type control panel and all the necessary electrical equipment. It is arranged for motor drive and includes an additional top roll which increases the capacity. Vertical rolls are fitted for use in conical rolling. When the machine is fitted with a 16" diameter top roll it is capable of bending mild steel plate 10' wide by 1" thick. With an 18" diameter top roll it can deal with plate 10' wide by 1¼" thick.

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Illustration shows series PBE 810 with swing-down bearing bracket in down position. Photo by courtesy of Consett Iron & Steel Co. Ltd. Durham

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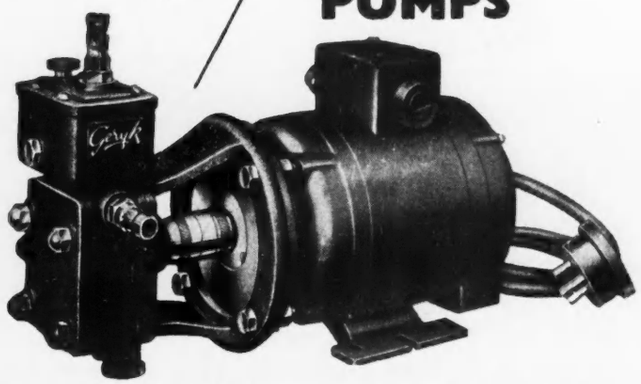

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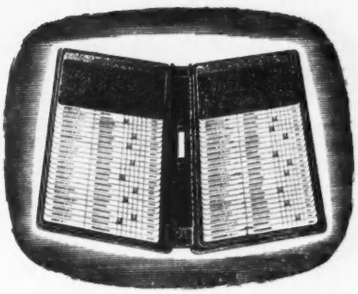

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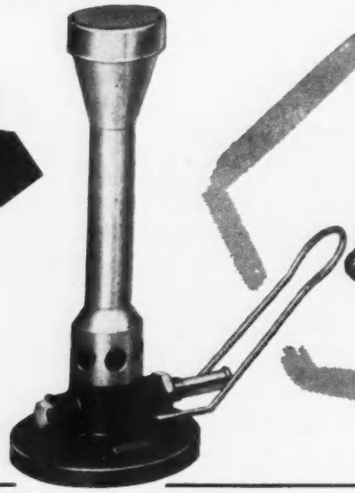

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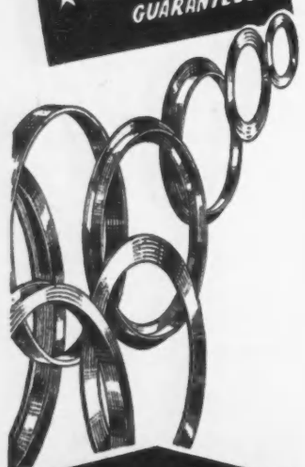

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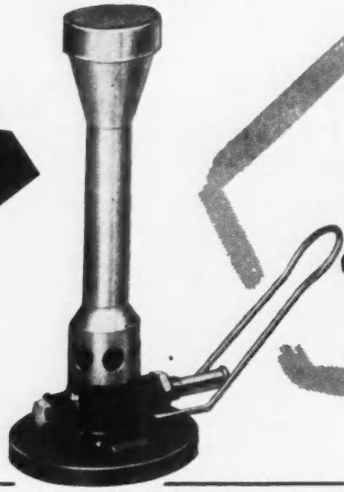

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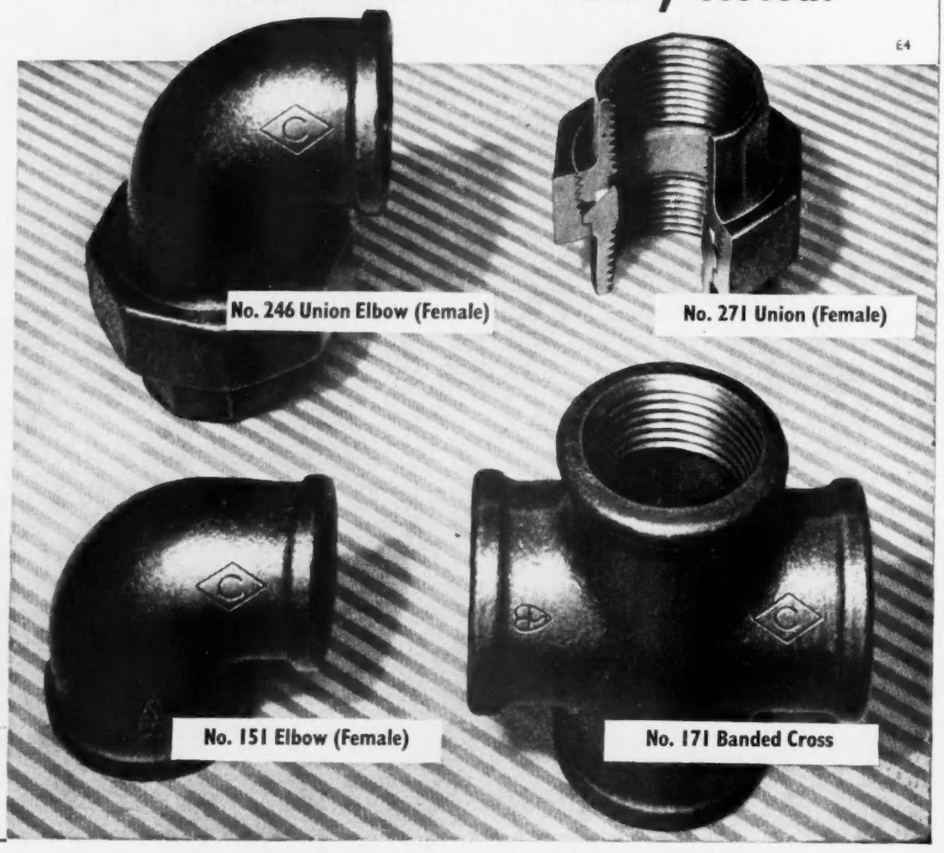

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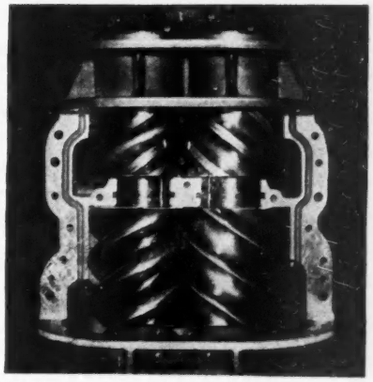

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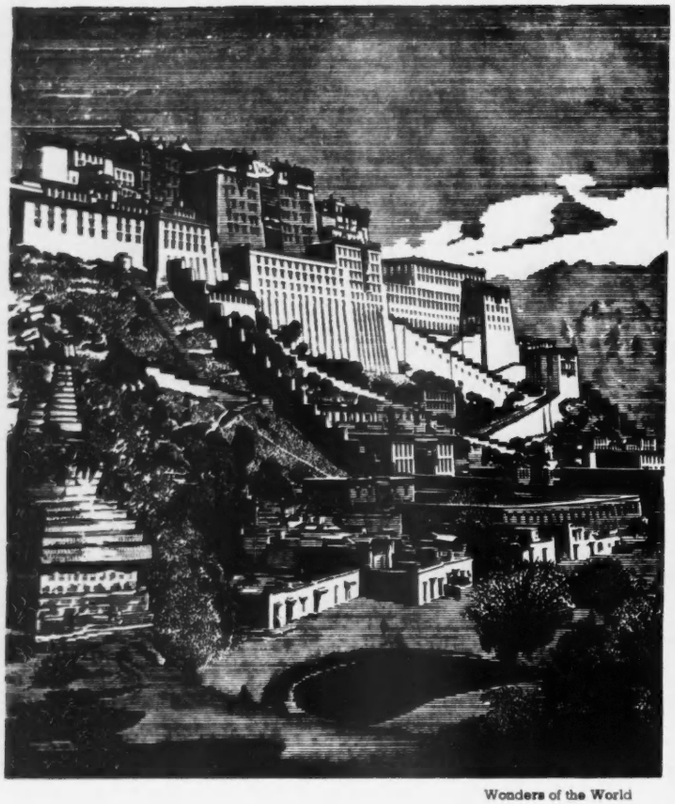

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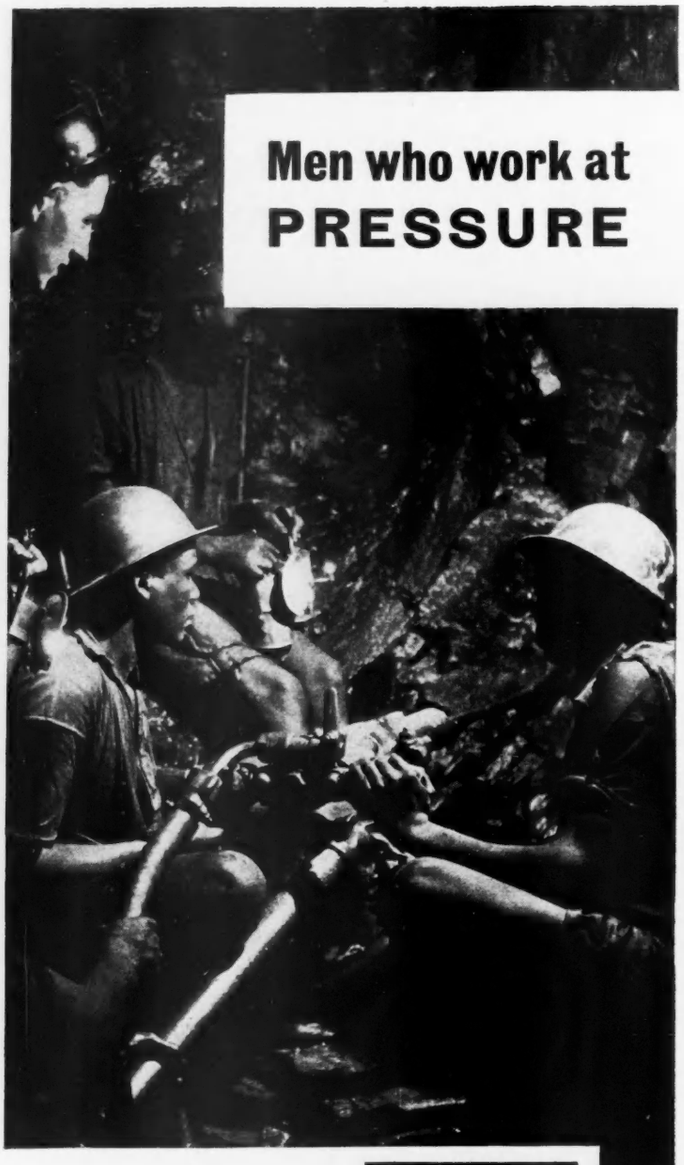

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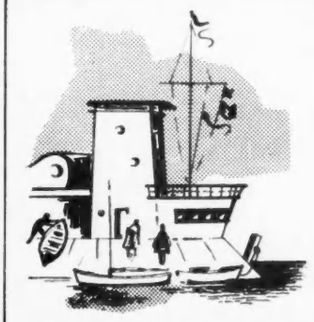

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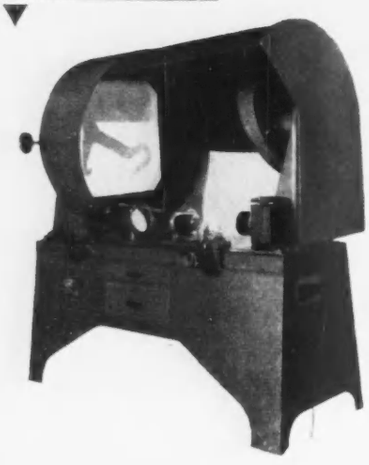

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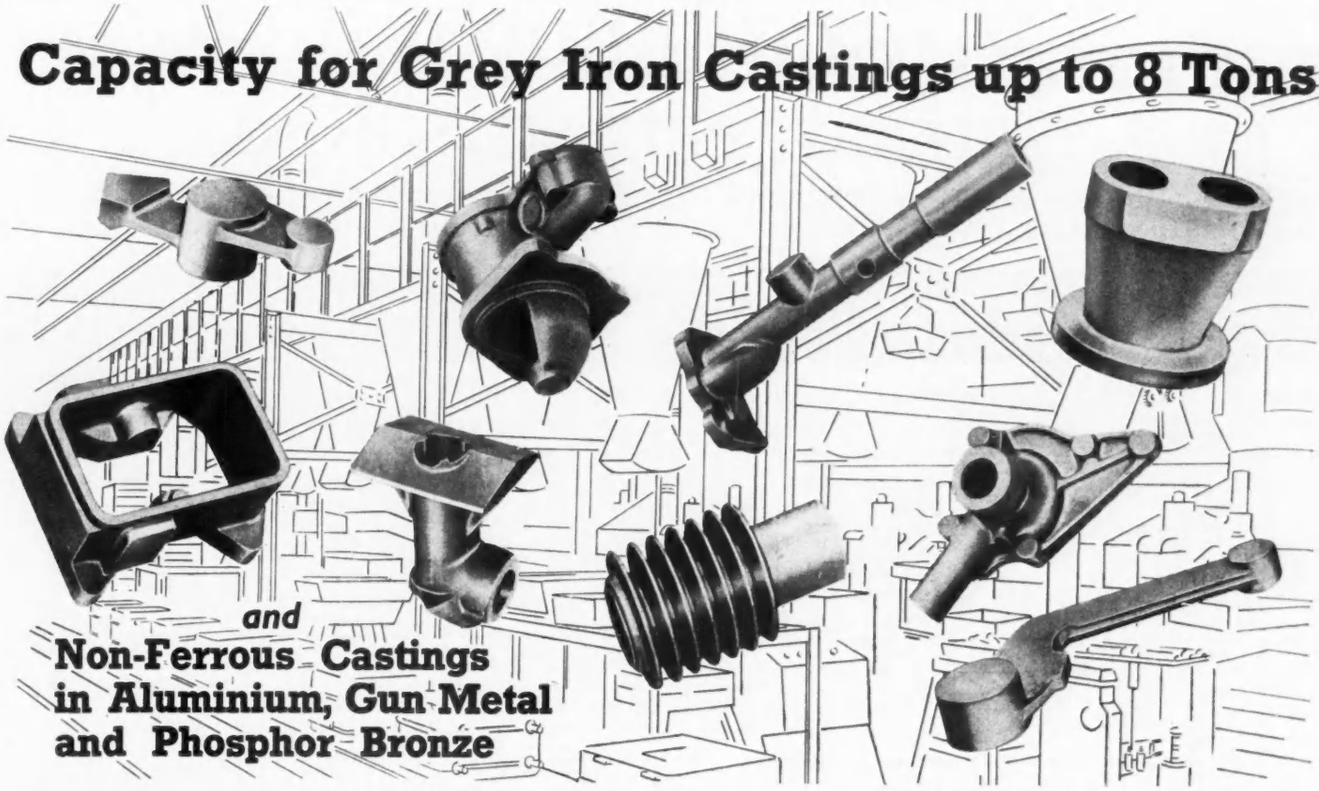

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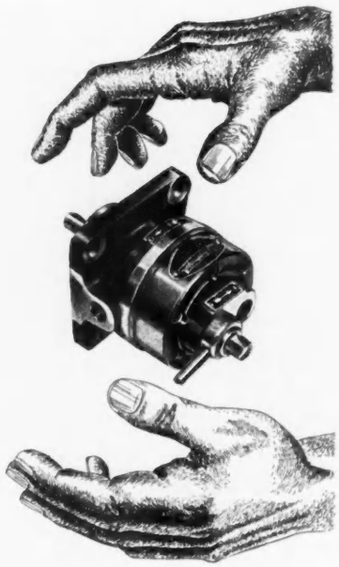

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HIGH DUTY ENGINEERING	E	14	26	56	10	170–190	12–15	7·20	—	—	5·0	14	25–30	1/10
	D	17	30	68	15	180–210	16–18	7·25	—	34,000	7·0	17	35–40	1/10
	C	20	36	75	20	200–240	18–20	7·40	—	51,000	9·0	20	40	1/8
	B	23	40	80	25	220–280	18–20	7·45	—	60,000	10·0	23	50	1/8
	A	26	45	90	30	260–340	18–20	7·45	—	73,000	11·0	26	60	1/8–3/16
HEAT RESISTING	HR.1	14	26	56	10	100–170	10–12	7·00	12·8	—	—	—	—	1/10
	HR.2	20	36	75	20	200–240	18–20	7·40	12·8	—	—	—	—	1/10–1/8
	HR.3 (Silal)	12	—	—	—	210–280	17–45	6·9–7·2	12·9	—	—	—	—	1/8
WEAR RESISTING	W.R.B.	20	36	75	20	240–280	18–20	7·40	—	—	—	—	—	1/8
	W.R.A.	26	45	90	30	260–340	18–20	7·45	—	—	—	—	—	1/8–3/16
CORROSION RESISTING	C.1	18	30	62	10	180–210	12–15	7·15	—	—	—	—	—	1/10
	C.2	15	28	58	10	180–210	12–15	7·15	—	—	—	—	—	1/10

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	D	Valve Bodies, Gates, Covers, Medium Machine Bedplates, Chucks, Gears, and Housings ; Cylinder Liners, Blocks, and Manifolds. All medium size high-pressure castings.	1/4"	
	C	Turbine Casings, Condenser Bodies, Tyre Moulds, Marking-off Plates, Propellers, Flywheels, Pump Bodies, Pistons, Large High-pressure Valves, Steam Chests, Biological Shields, Gears, Large Machine Bedplates, Headstocks, etc.	3/8"	For improved strength and toughness oil-quench at 850° C and temper at 300°–500° C to remove quenching stresses Grades C and B only.
	B	Diesel and Compressor Bodies (handling high-pressure ammonia and Freon gas), High-pressure Valves, Oil Well Castings, Slush Pumps, Gears, Machine Tool Components, Rocking Links, Highly Stressed Hydraulic Castings, Winch and Winding Drums, Rolls, etc.	1/2"	
	A	Crankshafts, Camshafts, Mixershafts, Dies, Rolls, Atomic Engineering Pressure Vessels, Shields, and Casings ; Brake Drums, High-pressure and High Strength Castings.	1/2"	For high tensile and machinability can be held at 300°–350° C, for six hours plus one hour for each inch of thickness.
HEAT RESISTING	HR.1	Intermittent Heat and Severe Thermal Shock, Chills, Ingot Moulds, Slag Pots, Annealing Glass Moulds, Fire Doors, Casings, Pig Moulds, Melting Pots, etc.	3/8"	—
	HR.2	High Duty Castings for use at temperatures up to 550° C, High-pressure Valves, Superheater Headers, Glass Moulds, etc.	1/2"	—
	HR.3	Castings working at temperatures up to 900° C, Valves, Fire Bars, Annealing Boxes, Furnace Parts. These castings are brittle at room temperature.	1/2"	—
WEAR RESISTING	WR.B	Chute Liners, Crane Wheels, Mill Wheels and Blades, Mixing Pans, Gears. Easily machinable.	1/2"	Can be oil-quenched at 850° C and tempered at 300°–500° C.
	WR.A	Mixer Blades, Wheels and Pans, Die Blocks, Cams, Gears, Liners, Rolls. High strength coupled with abrasion resistance.	1/2"	For high hardness castings, to improve machinability hold at 300°–350° C, for six hours plus one hour for each inch of thickness.
CORROSION RESISTING	C.1	Concentrated acid-resistant Pumps, Valves, etc.	1/4"	—
	C.2	Alkali-resistant Pumps, Valves, Caustic Pots, Evaporators, etc.	1/4"	—

New Alloys and Metallurgical Techniques employed in the process of producing these irons ensure consistent results, so that designers may rely upon the accuracy of the technical information given on the chart

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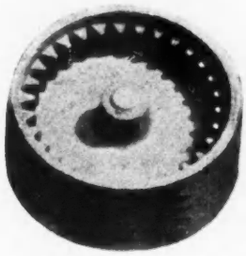
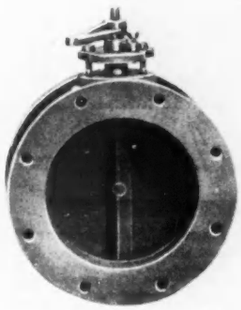
CASTINGS
IN 'CORTITE' IRON



GEAR DRUM—GRADE E

These teeth must be cast true. They are not machined and must mesh perfectly.

CORTS THROTTLE VALVE—GRADE C.



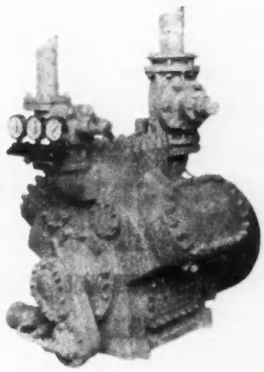
PUMP CASTING—GRADE D.—(For Hayward, Tyler & Co., Ltd., Luton).

This 53 cwt. Vertical Compound Oil Cargo Pump is for use in tankers and handles 750 t.p.h. of oil. It is tested at 350 lb. p.s.i. for a working pressure of 200 lb. p.s.i.

All the cores and the mould are made by the CO_2 process, which gives an excellent finish and ensures that the dimensions of cored holes are exact.

COMPRESSOR CYLINDER FOR REFRIGERATION EQUIPMENT—GRADE B.—(For Lightfoot Refrigeration, Ltd., Wembley).

This 15½ cwt. six-cylinder freon compressor casting must be completely flawless. The cylinders and crankcase, which are cast in one piece to ensure perfect alignment, are subject to hydraulic tests of 300 and 600 lb. p.s.i. respectively and gas tests of 250 lb. p.s.i.

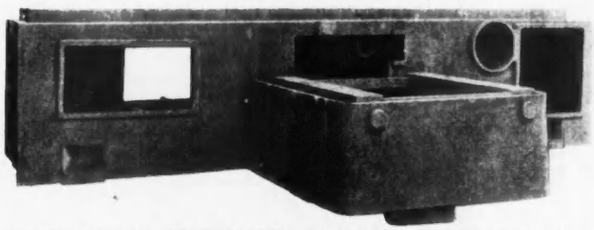


MIXERSHAFT — GRADE A.—(For Winkworth Machinery, Ltd., Staines).

This Casting must be very strong, and 100% sound, to withstand severe Torque, replacing a steel casting.

CORTS DOUBLE GATE VALVE—GRADE HR.2

For use in hot gas main at temperatures of 550°-600° C.



BEDPLATE FOR GEAR CUTTING MACHINE—GRADE C.—(For W. E. Sykes, Ltd., Staines).

This 3-ton, 12ft. long bedplate casting is only ¾in. thick and requires a very accurate mould and core, which, again, is achieved by the use of CO_2 process. Over 50 cores are needed to produce the intricate internal chambers.

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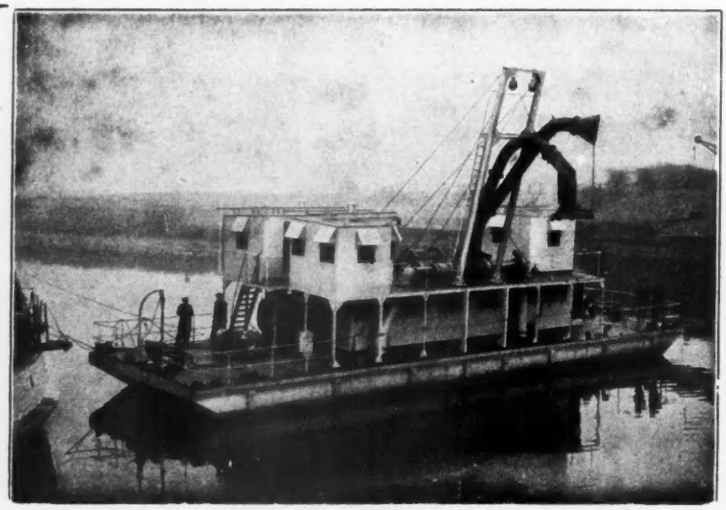
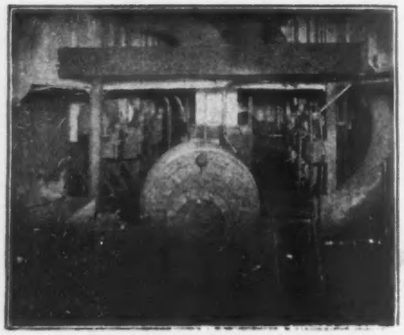


All Electric Reclamation Pumping Plant "Larubi" Constructed for the Anglo-Iranian Oil Co Ltd. Dimensions: 74 × 22 × 7 feet. Pumping capacity: 200 tons of mud per hour through 500 feet of shore pipe to a height of 30 feet above low water



Main Machinery Room showing High Efficiency Pump in foreground, with quick release beam for rapid inspection of pump.

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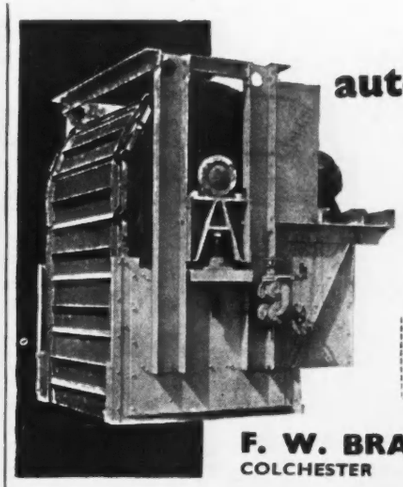

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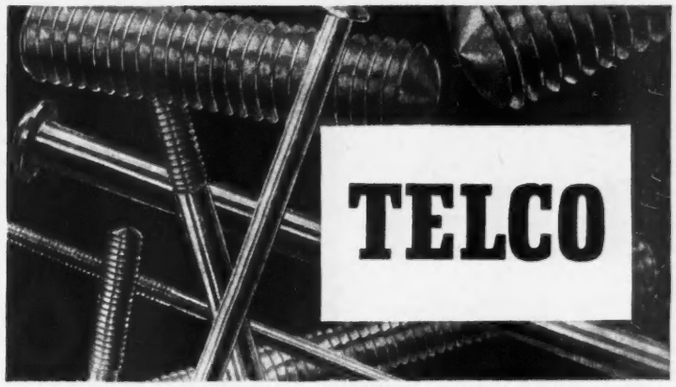

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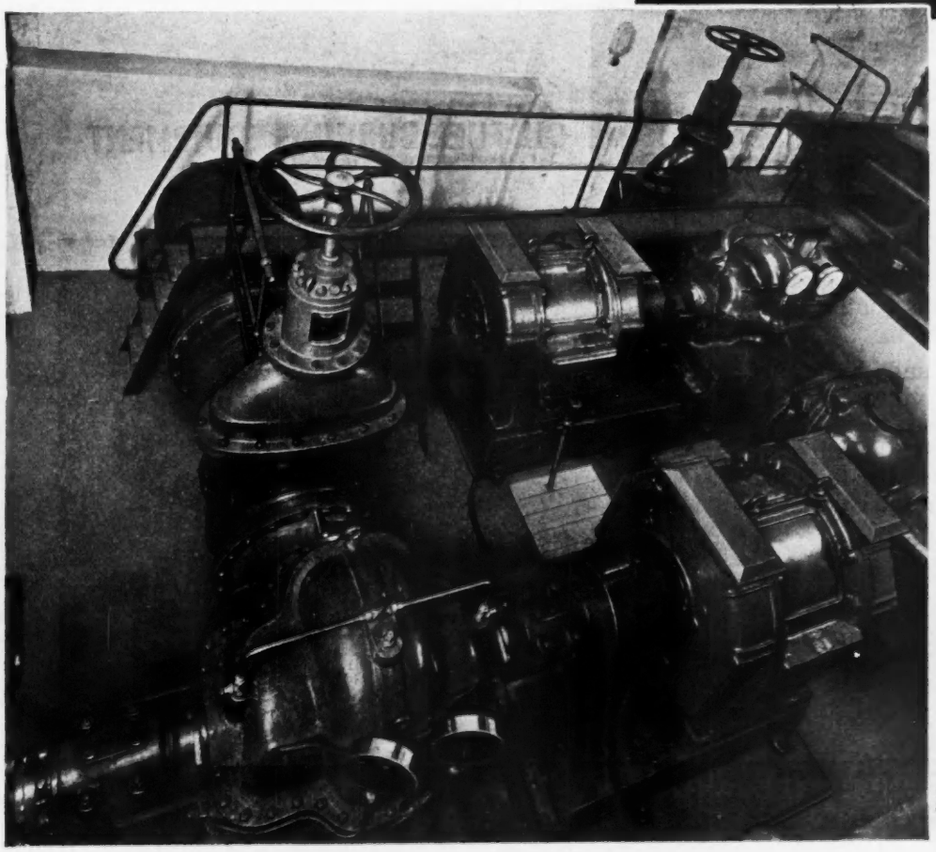

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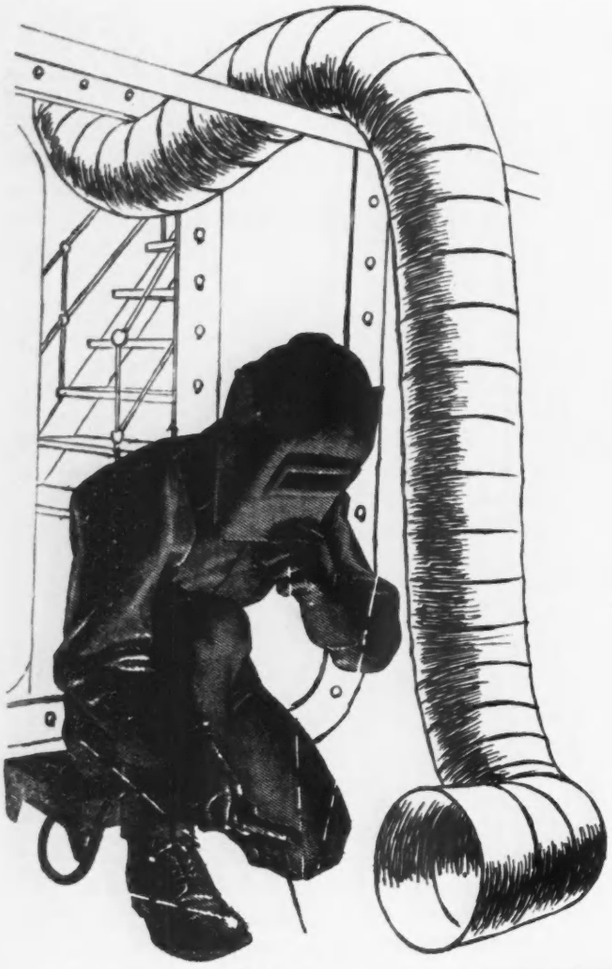

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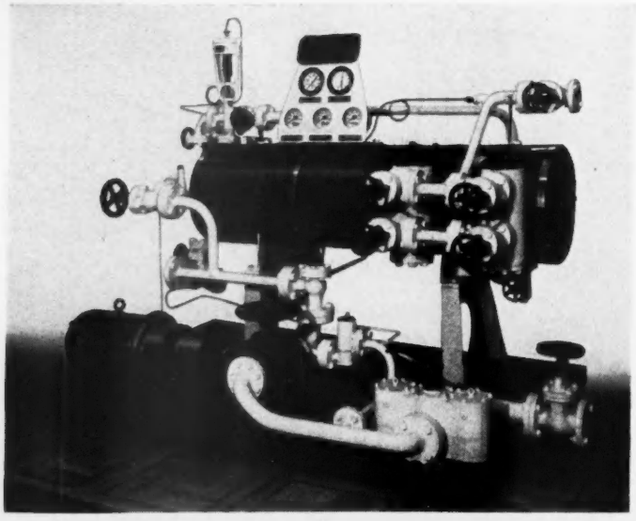
For particulars of Industrial equipment write for publication SEB. 99 which includes a questionnaire for completion and return to us.



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Long experience and extensive development bring to machine designers and users in this new equipment all the features of electronic drives in a simple compact easy-to-use form at an economic price.

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EASY TO INSTAL, just connect the a.c. supply and the motor—low in installation as well as first cost.

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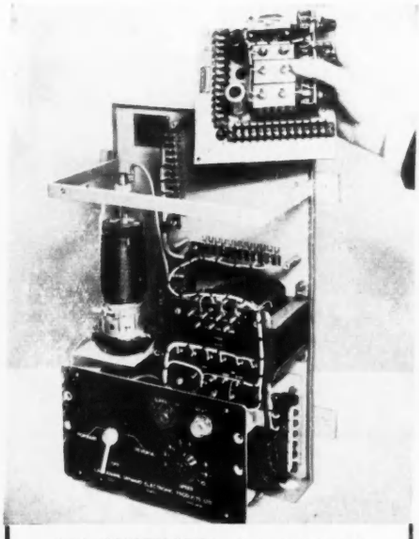

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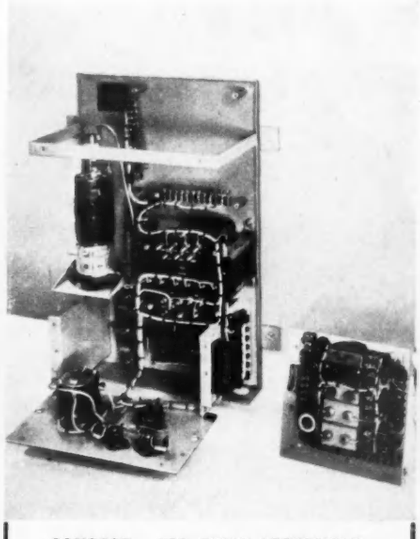

COMPACT — YET FULLY ACCESSIBLE, the flat back wall mounting design and hinge forward control panel enable all components to be reached without difficulty.

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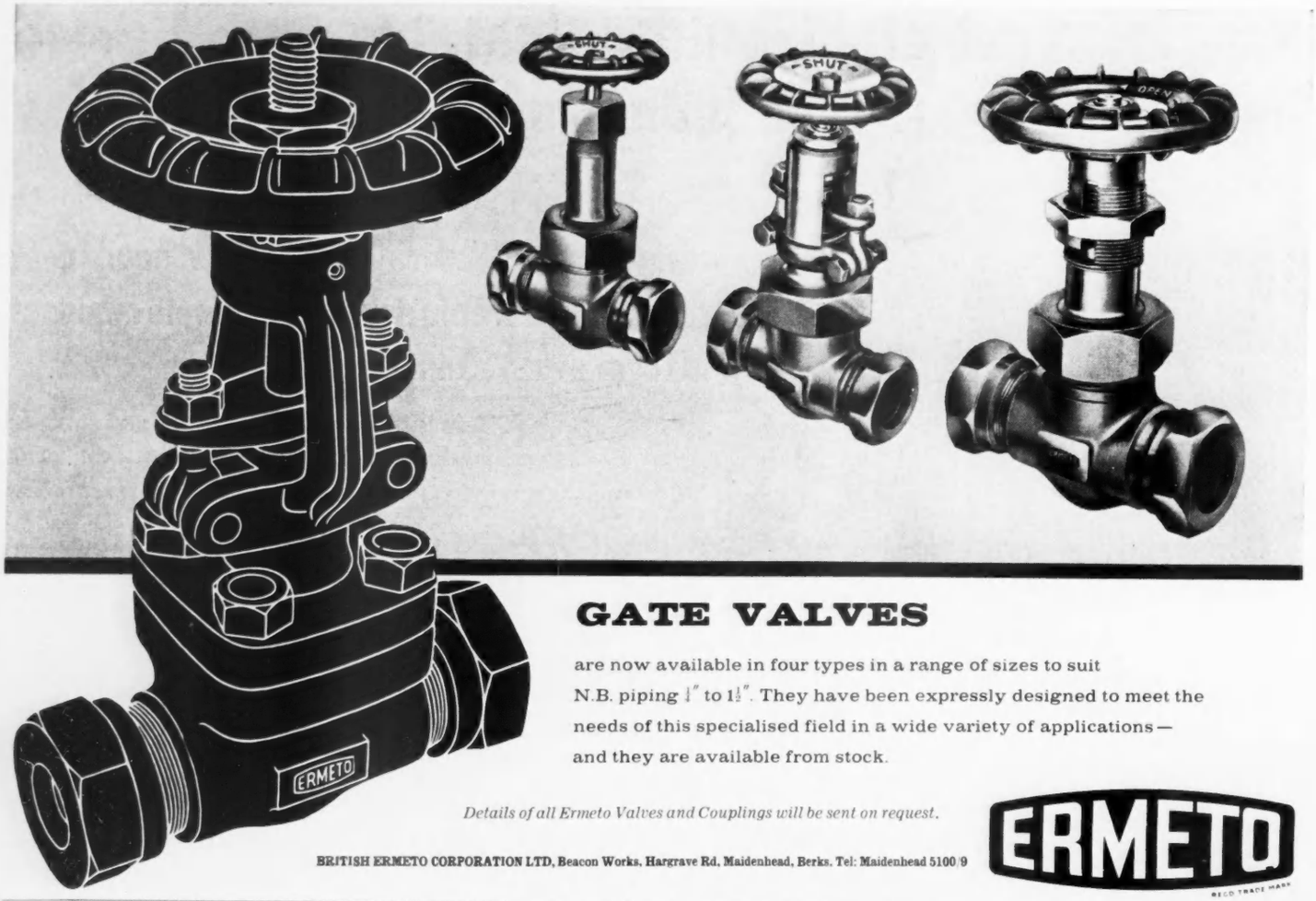

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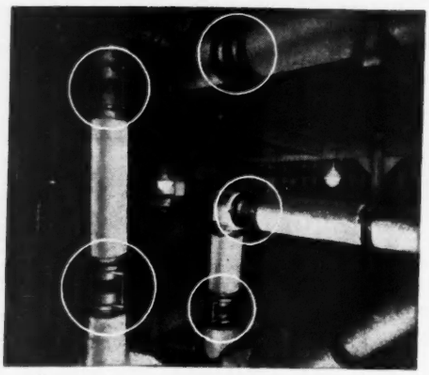

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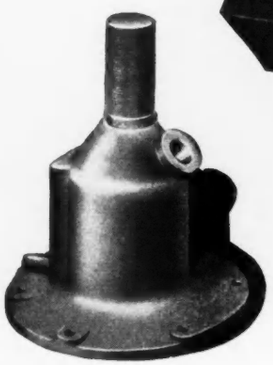

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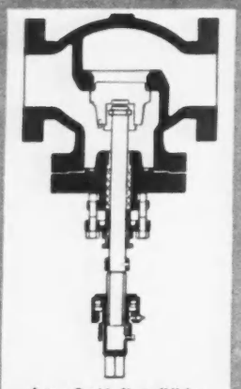
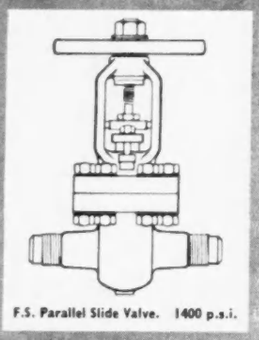
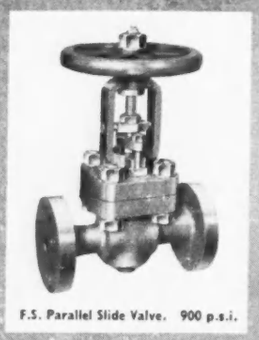
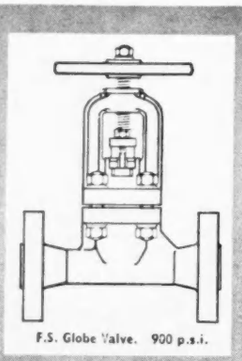
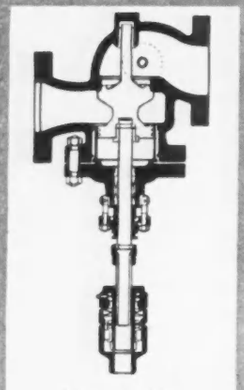
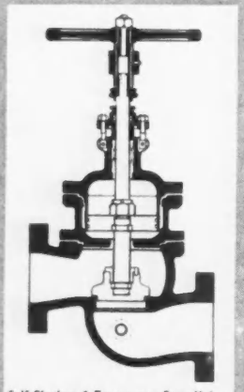

Astern Double Shut-off Valve.


F.S. Parallel Slide Valve. 1400 p.s.i.


F.S. Parallel Slide Valve. 900 p.s.i.


F.S. Globe Valve. 900 p.s.i.


Manœuvring Valve.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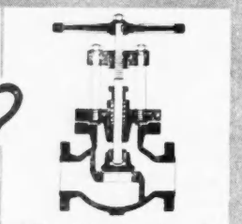
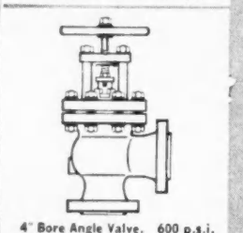
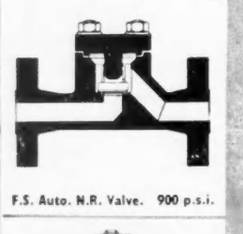

5" Bore Globe Valve. 600 p.s.i.


4" Bore Angle Valve. 600 p.s.i.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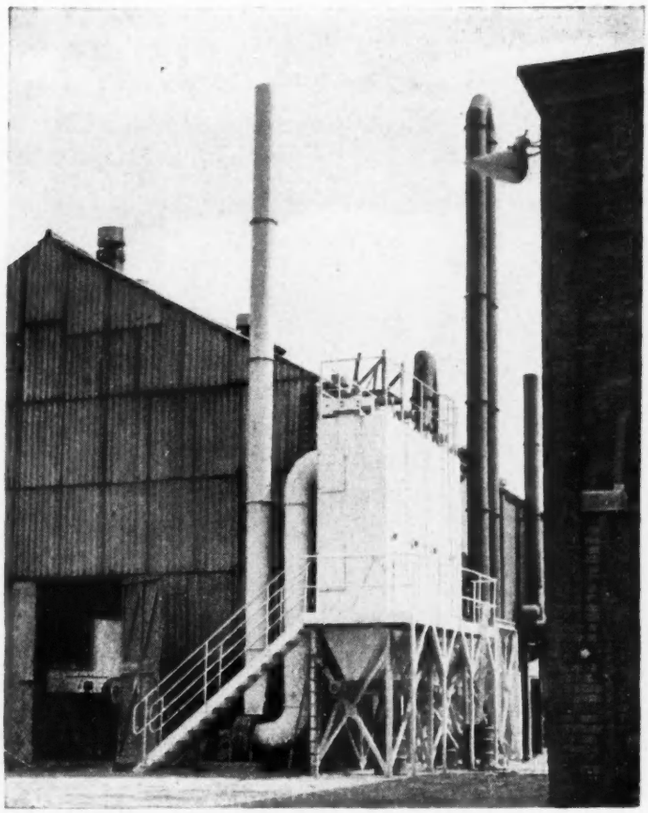

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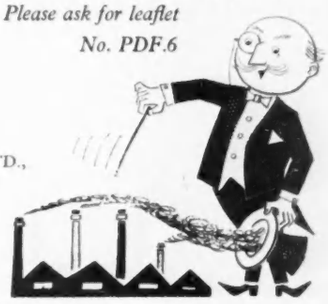

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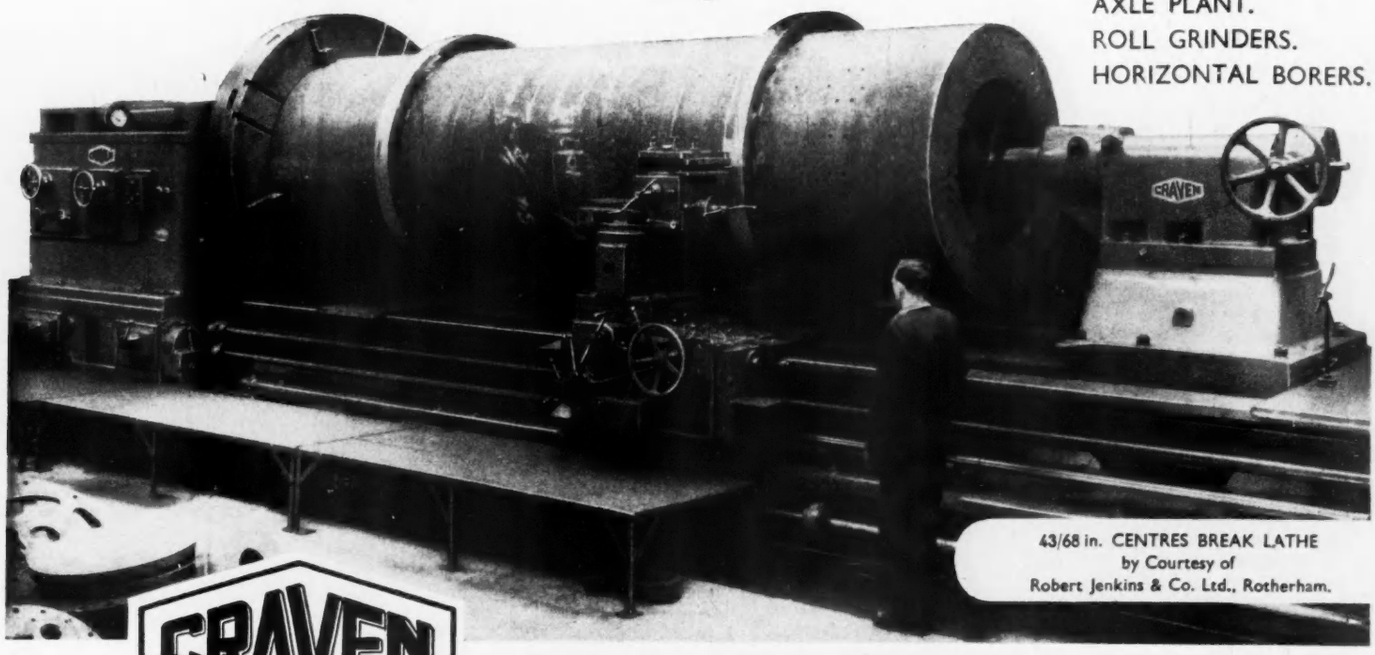

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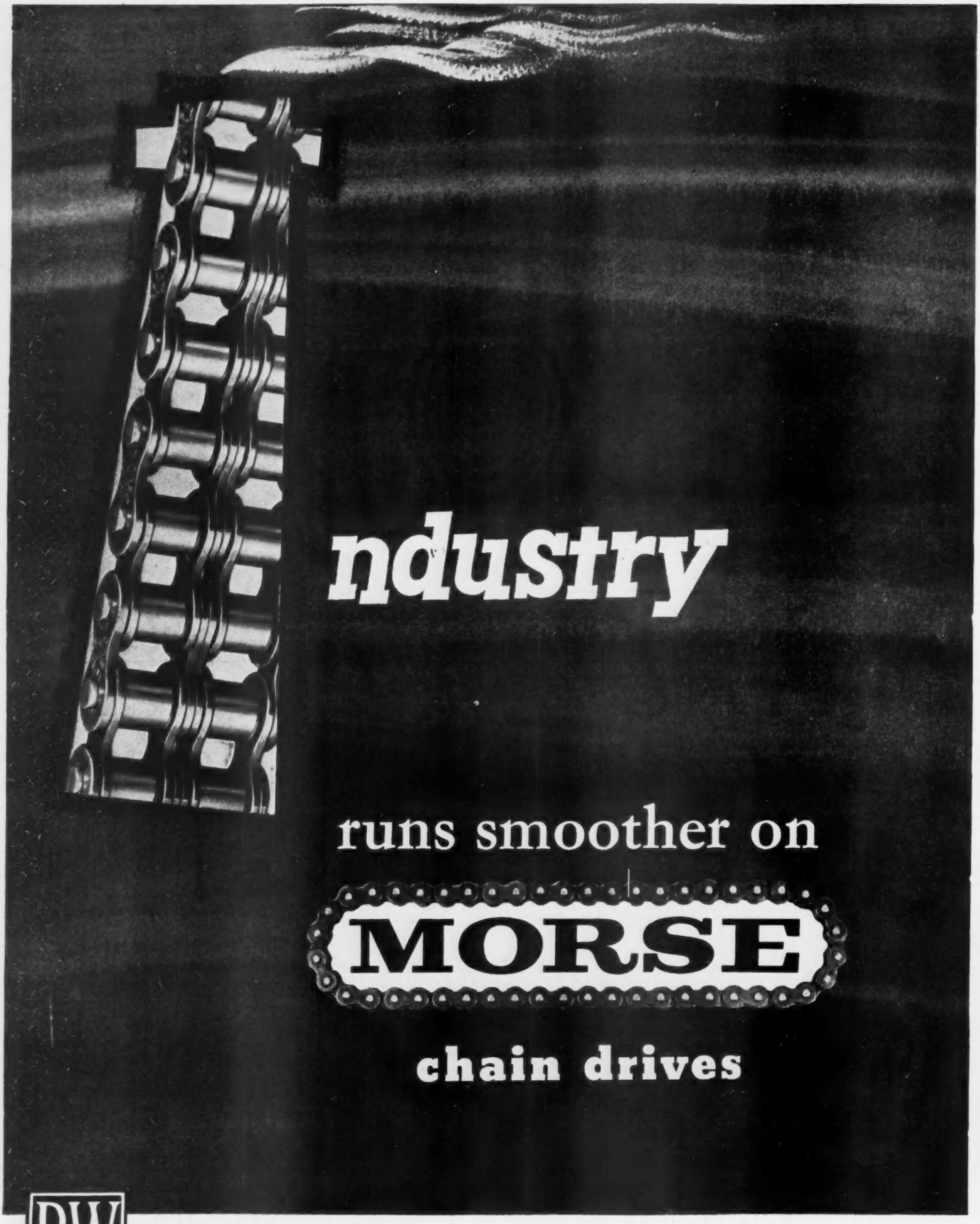

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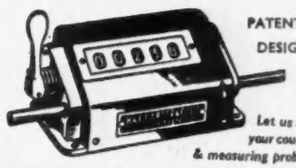

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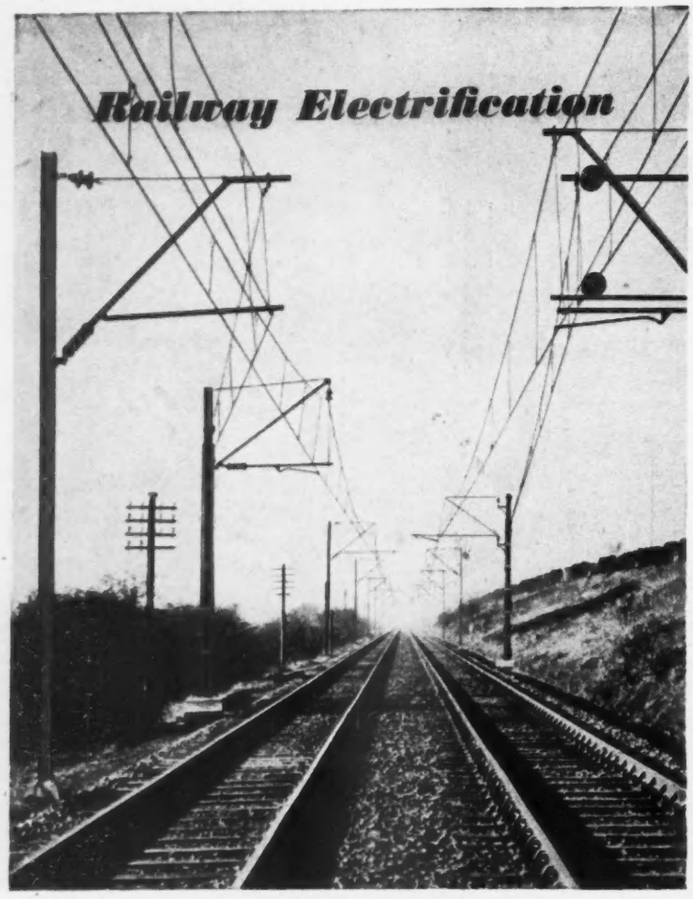

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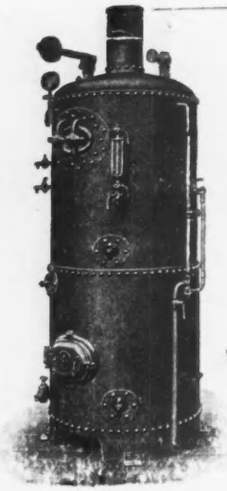

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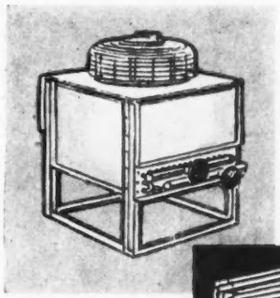

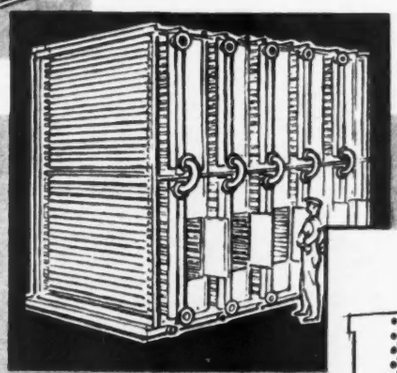

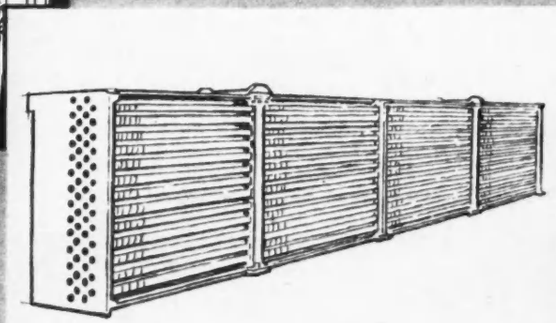

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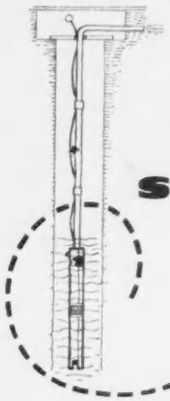

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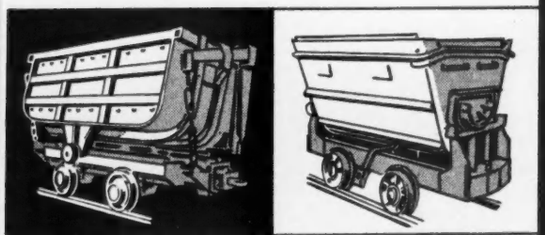

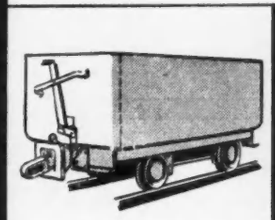

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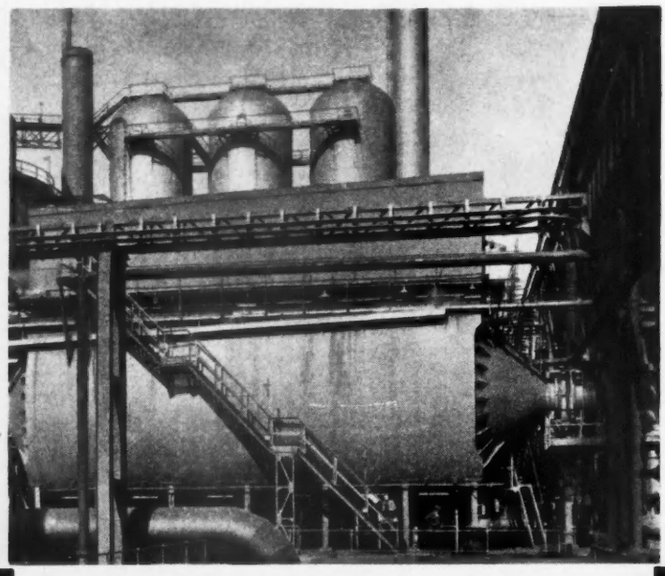

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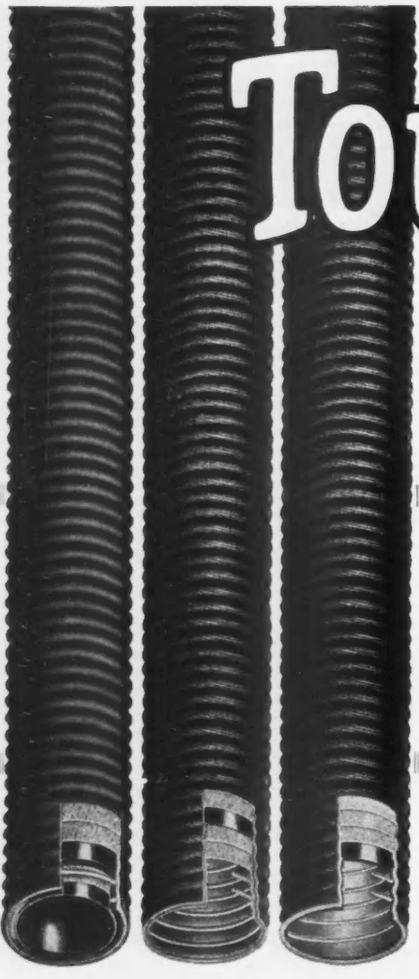

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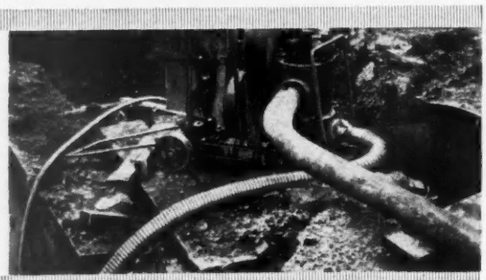

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THE ENGINEER

No. 5365 NOVEMBER 21, 1958 VOL. 206

OUTSIZE LOADS ON MOTORWAYS

Last July, when an Order was approved by Parliament excluding vehicles carrying abnormal indivisible loads from using the Preston by-pass motorway, due to be opened on December 5, certain road haulage organisations strongly objected. But it seemed clear to us at the time that the Minister was merely giving himself the powers necessary to carry out certain experiments on that motorway before formulating more permanent regulations which could be applied to the much longer Birmingham motorway, due to come into use in about twelve months' time. So it has proved. There are arguments which seem good to road haulage organisations why abnormal loads should be able to use the motorways. Notably there are the forceful ones that ordinary roads which have sharp corners and low bridges and pass through built-up areas, or which are so narrow that other traffic has to be specially warned of the approach of the outsize load, could be avoided ; and that the outsize load could be carried to its destination more rapidly, more safely and at less cost along motorways than along other highways. But there are forceful arguments to the contrary. The intention of a motorway is to provide for high speed, safe and unobstructed movement of motor vehicles. Unless, therefore, it can be contemplated that vehicles carrying outsize loads will travel at the high speed of the rest of the traffic such vehicles must inevitably prove obstructive, merely because they will be moving at a speed lower than that of other goods vehicles. Additionally, should the load be abnormally wide so that more than one traffic lane is obstructed, vehicles carrying such loads could create points of quite acute danger, since drivers travelling at high speed on a motorway will not be expecting the roadway width to be locally constricted anywhere.

In order to determine which of these arguments is the sounder, the Minister has made two decisions. First, any vehicle carrying a load not exceeding 12ft in width (this is the width of one lane of the motorway carriageway) may be permitted to use the Preston by-pass, subject to authorisation by the Chief Constables of Lancashire County and Preston County Borough. But no vehicle carrying a load exceeding 12ft in width will be authorised to use the by-pass during December, February and alternating months thereafter ; in other months such vehicles will be selected for authorisation according to width and other factors from time to time. By this means it is hoped to get firm information about the effect on traffic conditions and upon the safety of the motorway of permitting vehicles carrying unusually wide loads to use it. Vehicles carrying normal loads not exceeding 9ft 6in wide will, of course, be able to use the by-pass at any time and without notice. But those concerned in moving a vehicle carrying an " abnormal indivisible load," whether more than 12ft wide or not, will still need to advise the authorities before entering the by-pass.

Apart from width—it is possible that an over-wide vehicle may be shown by the experiment invariably to create dangerous conditions—it could be argued that the real criterion as to whether any vehicle should be admitted to a motorway is that it should be capable of attaining a minimum speed safely. For any slow-moving vehicle amongst the high-speed traffic of a motorway seems likely to create a hazard. But for certain practical reasons, minimum speed cannot be the sole criterion. For to apply it would be to ask an impossible task of the police, who would be unable to evict any individual vehicle until they had first called upon its driver to reach some minimum figure and then by measurement shown that that minimum speed was not attained. The more practical approach is to ban from entry to motorways all classes of vehicle suspected of being unable to reach satisfactory speeds with safety ; and all classes of vehicle which might create hazardous conditions, even though capable of travelling sufficiently fast. It should, however, be open to the makers or users of vehicles so banned to show that they would, in fact, create no hazards. By permitting experimentation on the Preston by-pass, the Minister, so it seems to us, is adopting just that sensible and practical approach.

INDUSTRIAL DESIGN

Last week there was held at the Birmingham Exchange and Engineering Centre a very successful conference on " Industrial Design and the Engineering Industries." It was the first such conference to be held in this country and was organised by the Council of Industrial Design. Surprisingly little was said at the conference about actual designs and indeed after one speaker, with obvious pride, had illustrated certain products by slides there was immediate criticism from the audience of their appearance ! Very possibly the Council, in its wisdom, had warned the five speakers who presented " Addresses " that the purpose of the conference was less to discuss and criticise each other's designs than to discuss how best to bring industrial designers into the works. Amongst matters particularly stressed was the need to bring in the industrial designer, whether an outside consultant or a member of the firm's staff, as early after the original technical conception as possible, so that he could be welded at once into the design team which developed the project. It was also notable how much what was said at the conference related to the design of heavy engineering products to be used in power plants, engineering works, &c., as opposed to engineering goods to be sold to the lay public. No doubt it is the strong modern desire of managements to make pleasant the places where people work that has reacted to encourage the makers of heavier engineering plant to make their plant easier to look at.

The criticism can be offered and was made at the conference that industrially this nation is striving rather too self-consciously to improve the æsthetic design of its products. One hundred and fifty years or so ago it

would have occurred to nobody that any object could be so utilitarian that there was no need to design it for good appearance. Thus, there was no need at that time self-consciously to think of beautifying a useful article ; the action was automatic. We doubt, indeed, whether before that period any schism between utility and beauty had ever been perceived by mankind. All kinds of reasons have been suggested for the decline in standards of taste in the Victorian era. Yet it does seem to us that one of the reasons can be traced to the reaction of artistic people early in the Queen's reign against the spreading industrialisation. Was it just the smoke, the muck and the dirt which repelled them ? Or was it that all kinds of new things of quite peculiar shapes having apparently nothing in common with accepted artistic canons were coming into being ? At any rate, what happened was that many artistic people turned away from the reality of life to study the aridities of " art for arts sake." Commercial art was regarded as æsthetically unworthy. Industrialists, many of them self-made men, thus deserted by those who might have advised them, necessarily thought primarily in terms of the utility of their products, claiming, far more strongly than the facts warranted, that fitness for purpose must create its own beauty. Soon it became difficult to believe (see some of Ruskin's statements) that any useful thing could be beautiful or that any beautiful thing could be useful ! It is from that slough of despond that we are trying to struggle to-day.

But after believing for so many decades that there must be a sharp distinction between utility and beauty, we cannot expect quickly to create designers who combine high technical talents with artistic perceptions, as some of the engineering pioneers did. The tendency, therefore, is to ask a technical designer and an " industrial " designer to work side by side on any new design. On first perceiving this need, although misunderstanding it, firms often ask a " stylist " to " beautify " an existing product. He clothes existing machinery, excellently fitted to serve its purpose, in shaped covers which do little to improve appearance and merely make maintenance more difficult. This stage can be equated with that which in architecture produced the Tower Bridge in London, the architectural detail of which has no relationship whatever with function. The oddity is, in fact, so marked in that structure that Londoners long since have taken the bridge affectionately to their hearts, just as we often become more attached to a shapeless but characterful mongrel dog than to a pedigree animal. Far less pleasurable in appearance, though equally odd, are flat irons and sewing machines and other household articles apparently designed for use at high subsonic speeds ! And perhaps amongst objects of the same wrong-headed style there can be included power stations so shrouded in stone and brick that they look like cathedrals. Calder Hall nuclear power station, we believe, nearly suffered the fate of having reactors and heat exchangers all hidden behind such a " dignified " facade. Fortunately, the attempt was found too difficult, with the consequence that a characteristic structural form has been created for gas-cooled graphite-moderated nuclear power stations of the future, with heat exchangers grouped around each tall reactor building and the whole set off by the long and low bulk of the turbo-generator hall. Fortunately, also, it is beginning to be recognised in industry—no doubt because the industrial designer is brought in from the beginning—that it is not necessarily æsthetic to cover up all working parts in what one of those present at the conference called " packing-case " design. For good æsthetic design and good utilitarian design go hand in hand. Only if the engineering designer and the artistic designer work together as a team can a firm feel sure that something produced to be fit for its purpose will also be fit to be seen. And, significantly, even in heavy engineering, other things being equal, that product which has the more pleasing appearance will sell the more readily. As the Council is fond of stressing, " Good Design is Good Business."

COAL

The National Coal Board is still finding it difficult to sell coal. In the first ten months of this year, inland consumption, at 169,472,000 tons, was 7,000,000 tons lower than in the comparable period of last year, while the amount taken up by exports and bunkers, a little over 4,000,000 tons, was 3,000,000 tons less. Total coal production so far this year, at 190,620,000 tons, is 7,000,000 tons below the corresponding figure for 1957, but the " undistributed stock " figure continues to grow ; it has now reached 18,053,000 tons and is thus more than double what it was a year ago. The Board makes no secret of the problems with which it is confronted. There is intensified competition from oil and there is less activity in industries which up till recently have consumed very large quantities of coal.

Inevitably, however, the present situation is one which cannot fail to be reflected in the Coal Board's finances. The " statement of production costs, proceeds and profit or loss of collieries " for the second quarter of this year, which has just been issued, reports an estimated deficit of £164,570, compared with an estimated surplus for the first quarter of £3,819,595. The Board's financial outlook is not a happy one. In recent months, the Board has done its best to effect economies of various kinds without jeopardising the long-term modernisation programme which is in hand. As the deputy chairman, Mr. Latham, put it in a speech last week, the Board, in meeting its present difficulties, " cannot afford to sacrifice output capacity to produce coal economically which will be needed in future years." One of those " present difficulties " springs from a wage claim that has now been referred to the industry's national reference tribunal. The Board's offer to increase daymen's wages by 7s. 6d. a week, subject to a nine-months' standstill on piece rates and to Saturday working at some selected pits, has been rejected by the National Union of Mineworkers. The union, after a coalfield vote, asked the Board to amend its offer " by removing or modifying the conditions." The Board has indicated its inability to do so. That is a reasonable decision, for the " selected pits " for Saturday working are obviously those from which large coal is obtained. The larger sizes of coal are those for which there is a demand during this season of decline. It is good business to use every endeavour to supply what the customer wants ; the production and sale of bigger tonnages of large coal is a more remunerative exercise than adding to the stocks of small grades for which, at present prices, there appears to be very little demand.

FREE TRADE IN THE DOLDRUMS

It has been apparent for several weeks that negotiations towards the setting up of a Free Trade Area around the European Common Market have not been going well. Now, following upon a statement by M. Soustelle last week, Britain has postponed indefinitely any more negotiations towards the setting up of that Area. On January 1 Belgium, France, Italy, Luxembourg, the Netherlands, and Western Germany will all make the first reductions of tariffs amongst themselves. But since it now seems certain

that no Free Trade Area will have come into being no such reductions of tariffs will be offered to other European countries. It has become doubtful, indeed, whether the concept of a Free Trade Area around the Common Market can now be realised at all. No doubt those who control certain industries and certain firms in this country will sigh with relief. But a greater number will feel, as we do, that unless negotiations can be re-established on a more satisfactory footing a great opportunity will have been lost and, worse, that a really retrograde step will have been taken. For ever since the war the Western European nations have co-operated within the Organisation for European Economic Co-operation in breaking down barriers to trade of various kinds. If the Common Market comes into being without the Free Trade Area around it, that co-operation must surely break down. Moreover, if the Common Market were to build around itself a high tariff barrier it is not easy to see how the tragedy of a tariff war could be avoided. Were Europe to become thus divided we hate to think what the effects might be upon the European Payments Union and even upon the Atlantic Treaty Organisation.

There is no doubt where the difficulty lies. It lies in France and among Frenchmen. But what exactly the difficulty is we find it less easy to determine. For if, as has been reported, it is the protectionism of French industrialists that leads to French resistance to the Free Trade proposals how comes it that those industrialists are willing to expose themselves to the competition that must arise within the Common Market ? More probably the difficulty is more subtle. Within the Common Market the French look to supranational organisations to bring about " harmonisation in the economic and social spheres." Perhaps they see no hope of such harmonisation being brought about within the looser concept of a Free Trade Area and thereby fear competition all the more. An alternative possibility is that those who took France into the Common Market had as their ultimate target the creation of a United States of Europe and that they see in a Free Trade Area something antagonistic to that concept. We cannot tell. Irritation, therefore, there must be in this and other countries interested in the Free Trade Area concept. For the French appear to have been neither able satisfactorily to define their objection to the existing proposals nor able to propose any alternative plan which would prove at all acceptable to the " Free Trade " nations. But surely it must prove obvious to all that to divide Western Europe economically in twain would benefit nobody, unless it was the U.S.S.R. A pause may be desirable to give the negotiators time to recover poise. But we find it difficult to believe that negotiations will not soon be re-opened.

LICENSING NUCLEAR REACTORS

The second reading of the Nuclear Installations (Licensing and Insurance) Bill was moved in the House of Lords last week by the Minister of Power, Lord Mills. As explained in our issue of November 7 the Bill has two main aims. The first is to introduce a system of licensing and inspection designed to make nuclear reactors on land subject to control in the interests of safety. The second is to impose an absolute liability up to £5,000,000 on licensees of nuclear reactors for injury or damage by radioactivity, with an obligation to take out approved cover. In granting a licence the Minister may lay down safety conditions affecting the design, siting and construction of a reactor as well as its operation and maintenance and may require the licensee to operate an effective monitoring system for detecting and recording the intensity of any radioactivity emitted from the reactor. Under the Bill licensing would not apply to the Atomic Energy Authority since the Authority's work is mainly experimental and is so advanced technically that it would be impracticable to subject it to independent inspection and control. On the other hand the Authority (and any other Government body that may operate a reactor) will be under absolute and unlimited liability to third parties for injury or damage by radioactivity. Furthermore, besides implementing the Fleck Committee's recommendations for improving safety arrangements, the Authority will be directed by the Prime Minister to observe the codes of practice laid down by the Minister's licensing department.

We feel that the Bill is important because it recognises the status of the nuclear reactor as an acceptable and respectable entity in the present-day industrial scene. Nuclear power is an immature industry but it is growing rapidly and its growth will be the more healthy if it is disciplined without being unnecessarily hampered. The main requirement is that control of the industry by inspection and decree should be sufficient for safety without being so heavy-handed as to retard progress. For there is a risk that regulations imposed by the licensing authority may tend to perpetuate the precautionary " belt and braces " philosophy that calls for a whole sequence of safeguards. To reconcile the demands of safety with those of economy and technical progress will require judgment of a very high order on the part of the Nuclear Safety Advisory Committee whose task it will be to give up-to-date technical advice to the Minister.

The Engineer—100 Years Ago (NOVEMBER 19, 1858)

" NAVAL WARFARE "

" The Government is making large additions to its fleet of screw frigates, notwithstanding the speculations as to an early change in the present mode of naval warfare. . . . We can quite understand, however, that it is difficult for the Admiralty to keep up with those who speak and write so confidently of *vaisseau béliers*, shot-proof batteries, and other offensive and defensive structures of similar character. What, indeed, are the naval authorities to think, when they are told that the Great Eastern alone, with a little internal strengthening, a shot-proof casing—if such a casing exists—and some forty guns, or so, firing ' molten iron-loaded shells,' would resist ' all the actual navies of the earth.' The introduction of the *vaisseau bélier* might be expected to reduce naval warfare to a system of chase and escape, which would eventually turn in favour of the sharpest hulls and most rapid propellers, combined with the quickest means of turning about. . . . The steam battering ram must necessarily expose a good deal of surface lengthwise, as in order to have suitable lines, and consequently speed, its sides must run straight, or nearly so, for a considerable distance. A circular floating battery, although presenting no point-blank surface, could not, of course, serve as a battering ram, nor could it be run at any considerable speed.

" It must not be forgotten either, that, with such extremely novel modes of warfare, we might also have a new system of submarine attack, for instance, Dr. Payerne's apparatus at Cherbourg, or the Nautilus. Although not much has been done in adapting these inventions to the destruction of vessels from below, we are quite certain that the appearance of a hostile *bélier* would be immediately followed by an arrangement for blowing it completely out of the water. It is very well known that such a thing is possible, whilst experiments might show its execution to be comparatively easy. Submarine blasting is yet a modern application, and we had only the other day an illustration of the effect produced by the explosion of a ton of gunpowder forty feet under water, in the destruction of the Vanguard rock. What chance would there have been for a vessel, with the same magazine exploded upon its hull, twenty feet under water ? "

Simulated Service Life Testing

By TIBOR HAAS, Dipl.-Ing., A.M.I.Mech.E., A.F.R.Ae.S.

No. II—(*Concluded from page 756, November 14*)

The discrepancies between the fatigue strength of parts in service and the fatigue strength of the material, determined on small laboratory specimens, led in recent years to the general adoption of full-scale tests on components and assemblies in a number of industries, thereby fulfilling the first requirement of realistic testing. The second requirement, which represents a departure from idealised and standardised test conditions, stipulates a close simulation of the loading actually met with under service conditions. This article, illustrated by examples taken from the aircraft field, describes a method and equipment used by Bristol Aircraft, Ltd., to keep pace with requirements of realistic endurance testing.

Design Features of Programme Loading Machine

A GENERAL view of the machine is shown in Fig. 6, as set up in the 30-ton loading range. At the far end, the control console is seen, while the right-hand corner shows the load-magnifying device on the frame which supports it when not in use. Fig. 7 shows a close-up view of the machine as set up in Fig. 6, and Fig. 8 gives a general layout of the functional parts which are common to both the basic machine and all the additional loading means, although the figure refers to the basic loading range. Fig. 9 shows the machine fitted with the load-magnifying device ; the support frame from which the magnifying device was lifted on to the machine bed is seen in the right-hand foreground, while the 30-ton crosshead in the left-hand corner is deposited on trestles while out of use. Fig. 10 is a close-up view of the driving end of the machine ; the identification symbols shown are the same as those in Fig. 8. The heavy machine bed or frame 1 (Fig. 8) rests on rubber blocks 2 (low frequency mounting), so that loads and vibrations are self-contained, and no special foundation is required. Both the fast and slow drive units and the mean load springs are mounted on a longitudinally moving carriage 3 which rests on slides 4. Carriage travel is obtained by a screw and nut drive via chain and reduction gearing driven by an electric motor. This drive 5 is situated at the end of the machine and its housing is rigidly bolted to the machine bed. The purpose of this arrangement will be described in connection with mean load pre-setting and application. Before doing so, a word of explanation is required as to the path of the loads generated to the specimen under test : all loads, i.e. the mean load and the loads generated by the fast and slow drives, are transmitted to the specimen via the vibrating head 6 which is supported on the carriage 3 by means of parallel motion guide frames 7. These frames are linked to the vibrating head and the carriage by frictionless crossed spring pivots (flexure pivots), a design feature of which extensive use is made in the machine, whereby backlash in the various parts of the vibrating system is practically eliminated so that there are no losses which would increase the energy required for excitation.

(*a*) *The Mean Load Device.*—The mean load is applied by a pair of (left and right-handed) helical springs 8 (Fig. 8), situated transversely to and below the vibrating head and linked to it by lever 9 in the longitudinal centre plane. The outer ends of the springs are connected to mean load setting levers 10 on either side of the carriage. Levers 10 are held between stops in a position corresponding to the mean load required, which can be read off the attached scale on the carriage (Fig. 10). The stops are nuts on a screwed spindle fixed to the carriage and can be used for positioning levers 10.

If this is done prior to the fitting of the specimen to the vibrating head, the mean load is pre-set, the guide frames 7 being deflected from the vertical into an oblique position and the vibrating head moved accordingly. After fitting the specimen to the vibrating head and moving the carriage by using drive 5, until frames 7 are again upright, springs 8 impart an axial load, i.e. the pre-set mean load to the vibrating head, and thus to the specimen. The mean load is, therefore, due to the combined torsion and bending of springs 8, generated by the relative movement of their outer ends against the inner ends which were held by lever 9 while the carriage was moved by the amount required for restoring guide frames 7 to their vertical position from which they were deflected during the pre-setting procedure. (In Fig. 10 the mean load setting lever 10 is set for zero mean load, while in Fig. 7 a tensile mean load is applied.) The maximum mean load is 16 tons tension or compression for the basic machine, and 100 tons tension or compression with the load-magnifying device.

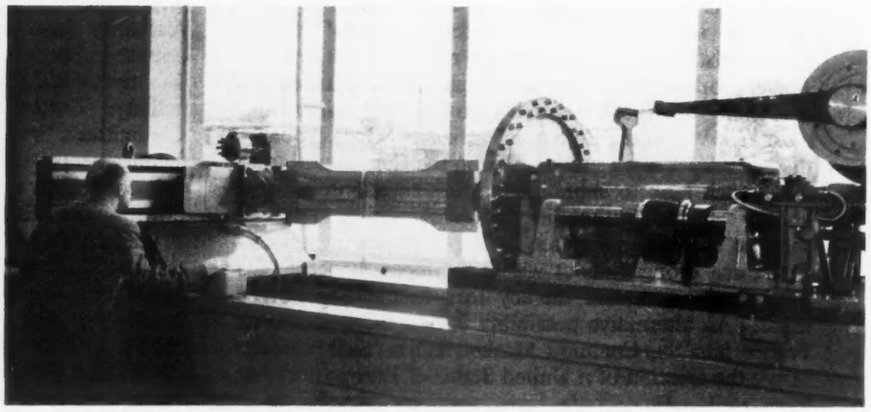


Fig. 7—Partial close-up view of machine with the same set-up as in Fig. 6

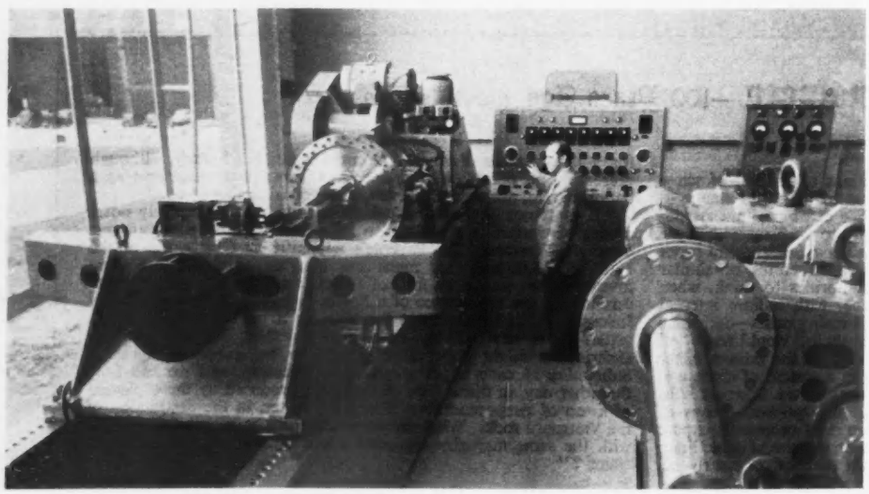
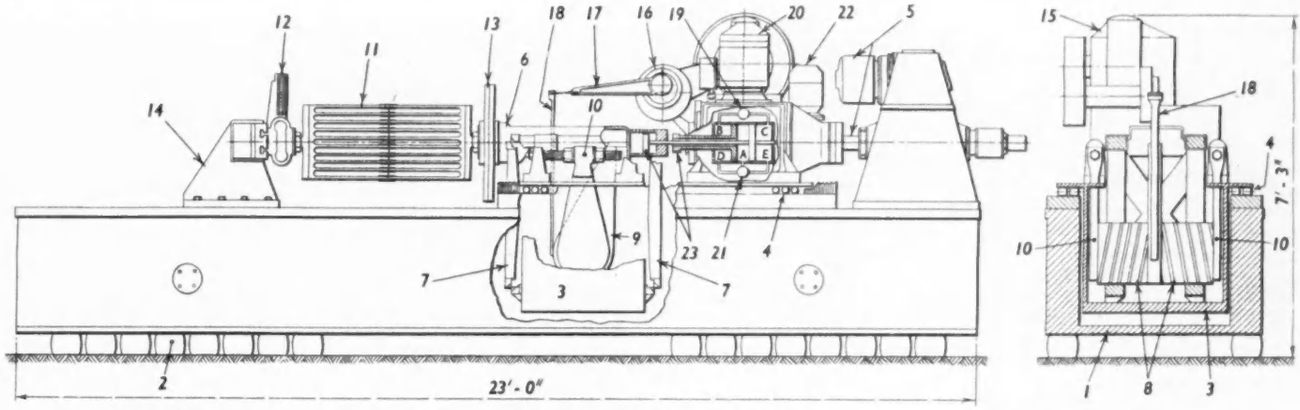


Fig. 6—Programme loading machine set up for a "stiff" specimen in the 30-ton loading range

(*b*) *The Fast Drive.*—With the fast drive, the machine operates on the principle of resonance. The resonating system, Fig. 11, is composed of two masses, of which m_1 is the relatively small mass of the vibrating head, and m_2 the large mass of the machine frame (approximately 25 tons). The spring of the resonating system interposed between the two masses consists of the specimen and the loop dynamometer, the latter being shown in the position in which it is most frequently used. Fig. 11 refers to the 30-ton load range in which two arrangements are distinguished, one for flexible specimens (*a*), the other for stiff specimens (*b*). In the latter case an additional dual disc spring must be used which increases the input deflection amplitude to an amount required by the slow drive and at the same time helps to keep the fast drive within the maximum 3000 c.p.m. The lowest speed with the fast drive is 350 c.p.m. The maximum alternating load ($\pm$10 tons) can be superimposed on the mean (up to 16 tons tension or compression).



1.—Machine bed.
2.—Rubber blocks (low frequency support).
3.—Moving carriage.
4.—Slides (shown schematically as rollers).
5.—Carriage drive.
6.—Vibrating head.
7.—Guide frames.
8.—Mean load springs.
9.—Mean load transmitting lever to vibrating head.
10.—Mean load setting levers.
11.—Test specimen.
12.—Dynamometer with reading screen.
13.—Dual disc spring.
14.—Cross head (for 30-ton load range only).
15.—Fast drive motor (resonance).
16.—Variable throw eccentric.
17.—Connecting rod.
18.—Exciter spring.
19.—Reversing pump.
20.—Slow drive reversing motor.
21.—Coupling pump.
22.—Coupling motor.
23.—Slow drive coupling jaws.

Fig. 8—General layout of programme loading machine as set up for a " stiff " specimen in the 30-ton loading range

When using the load-magnifying device, the resonating system conforms to the arrangement shown in Fig. 12 (*a*), irrespective of the specimen stiffness ; the basic range crosshead (14, in Fig. 8) being replaced as indicated by the dotted lines in Fig. 12 (*a*) by the load-magnifying unit with its own dynamometer for the 200-ton range. The speed range with the magnifying device is between 350 and 1000 c.p.m. The maximum alternating load is ± 60 tons, which can be superimposed on the mean load (up to 100 tons tension or compression).

The exciter drive and mechanism differs from the more commonly known systems[4,5] using a rotary out-of-balance mass as means of excitation because programming of loads requires operation at different frequencies and independence from the internal damping properties of various specimens. This is achieved by a spring-force exciter system consisting of driving motor 15 (Fig. 8), stepped pulley and belt transmission to a variable-throw eccentric 16, connecting rod 17, and the trapezoidal exciter leaf-spring 18. The latter is connected to the vibrating head via lever 9 and by the alternating bending applied to it, excites the head to vibrations near to the natural frequency. Because in this region the exciter need only have sufficient power to overcome frictional and damping forces without having to supply the dynamic load to the specimen, the power input relative to the loads and deflections in the specimen is very low. In fact, the vibrating system works on the rising branch of the resonance curve and thus the load is strongly frequency dependent. This requires accurate speed control which is taken care of by the electrical control system, but enables also a smooth change from one load level to the next. The test specimen, together with the dynamometer and the exciter are, of course, parts of the masses m_1 and m_2 ; however, they are relatively small and do not matter much from the resonance point of view. The natural frequency of the system can be altered by additional masses to be fitted to the vibrating head. (See Fig. 9 and compare with Fig. 8 ; in the latter there is no additional mass used, but three holes for bolting down the mass can be seen.)

(*c*) *The Slow Drive.*—The slow drive is obtained hydraulically by a pair of pistons in a cylinder which is pressurised from alternate ends (Fig. 8) by a reversing pump 19, driven by reversing motor 20. The change from fast drive to slow drive, and vice versa, is automatic, but while the resonance exciter spring is permanently connected to the vibrating head, the hydraulic drive has to be brought into engagement with the head before it can operate. For this purpose a coupling pump 21, driven by its motor 22, pumps hydraulic fluid through port *A* of the cylinder into the space between the two pistons, which thus move apart. The pistons have concentric piston rods, the ends of which form the coupling jaws 23 that engage the vibrating head when the pistons reach their outermost positions. (See Fig. 7, coupling " engaged," Fig. 10, coupling in " disengaged " position.)

Pressure of a prescribed magnitude is maintained in the space between the inner

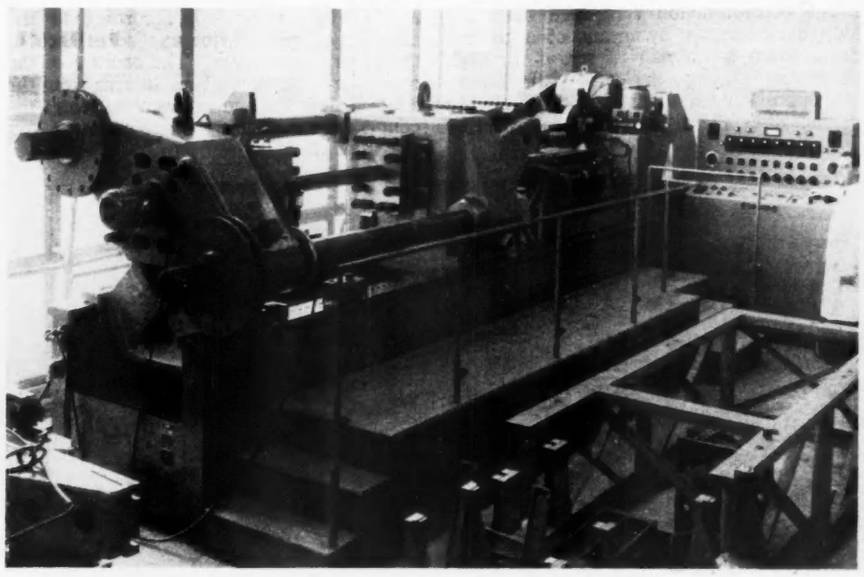


Fig. 9—Programme loading machine with 200-ton load-magnifying device

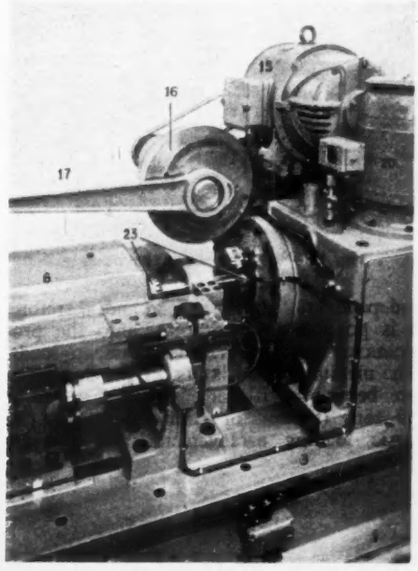


Fig. 10—Close-up view of the drive end of the programme loading machine. Part numbers are identical with those in Fig. 8

faces of the pistons throughout the operation of the slow drive so that the two pistons act as one when the reversing pump 19 supplies pressure alternately through cylinder ports *B* and *C* i.e. pump 19 sucks fluid from port *B* delivers it through port *C* and vice versa. Thus, the simultaneous reciprocating movement of both pistons is transmitted through the coupling to the vibrating head, thereby generating an alternating load in the specimen. For declutching the slow drive from the head, pump 21

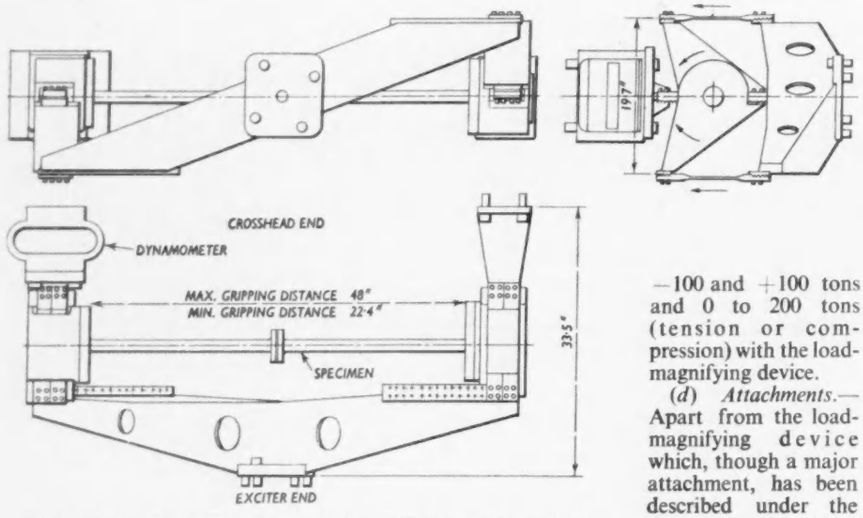


Fig. 11—Torsion loading attachment for ±18 deg. maximum twist

supplies pressure fluid simultaneously through ports *D* and *E*, while port *A* opens to drain via associated solenoid valves.

In contradistinction to the resonance generated loads which are applied about a constant mean load, the hydraulic loads are

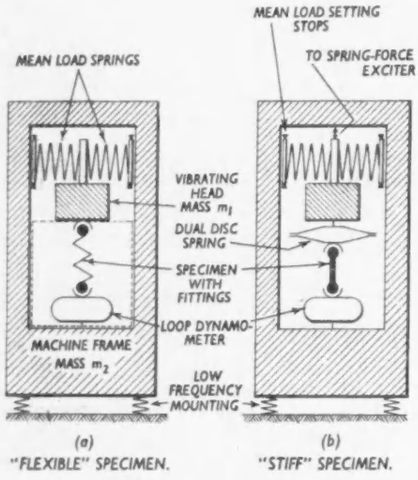


Fig. 12—Principle of the resonating system

independent of the mean load and, therefore, it is possible to incorporate into the programme, stages with different mean loads. The maximum load limits for the slow drive are between −16 and +16 tons and 2 to 30 tons (tension or compression) for the basic loading arrangement, and between −100 and +100 tons and 0 to 200 tons (tension or compression) with the load-magnifying device.

(*d*) *Attachments.*—Apart from the load-magnifying device which, though a major attachment, has been described under the foregoing functional headings, the machine is provided with separate bending and torsion loading attachments which operate in the 30-ton load range. The bending attachment enables cantilever, three-point loading (Fig. 13) and four-point loading (Fig. 14) arrangements to be set up. For this purpose, the crosshead support is used in a reversed position, when loading is applied by a rod, one end of which is attached to the vibrating head, the other end to bending shackles (or shackle) which are clamped to the specimen.

The torsion loading attachment is shown in Fig. 11. An oblique beam is attached to the vibrating head ; the ends of the beam are equidistant from the specimen, but one end is above, the other below, the specimen. Consequently, with suitable levers a pure torsional couple is applied to the specimen. The dynamometer is at one end of the beam and opposite the lever arm, so that half the applied load is measured by it. The maximum total moment (mean plus alternating) with these attachments is plus or minus 29,000ft lb.

(*e*) *The Electric Controls.*—For the high mechanical performance of the programme loading machine reliance is placed on an electric control system of great sensitivity. It is not possible to go into details, and therefore only those elements of the system will be mentioned which have some bearing on the setting of the machine.

The control action is derived from the loop dynamometer by means of a control drum which has a pair of screws for each programme stage ; the ends of the screws are opposite each other and carry electric contact discs, the distance of which is set by the screws with reference to the desired dynamometer readings (Fig. 7). The axial deflections of the dynamometer are transformed into angular movements of a vibrating arm, the end of which touches the contacts of the drum alternately. For the slow drive, the current impulse obtained by the vibrating arm touching a contact disc in the drum is used for reversing the motor of the drive pump. With the fast drive, frequency control is obtained by the time of dwell of the vibrating arm at the contacts of the drum ; thus, for instance, if the frequency drops, i.e. the speed of the exciter motor falls, the time of dwell at the contacts diminishes, and control action is initiated for an increase of frequency. With the dynamometer at the rigid end of the machine, the automatic electric controls cater for load constancy irrespective of the degree of inelastic extension the specimen may undergo during the course of the test. This involves not only the described constancy of load-amplitude for the fast drive, and the constancy of load limits for the slow drive, but also the constancy of the mean load. The control of the latter, as with the fast drive, is derived from the time of dwell of the vibrating arm at the contacts of the control drum. Changes in mean load are compensated by movements of the carriage (3, in Fig. 8) ; if inequality of dwell relative to a pair of contacts occurs, a control impulse is received which actuates the carriage drive motor (5, in Fig. 8) until equality of dwell at the contacts is restored.

As load setting must be done with reference to the dynamometer, a remote control box is provided. When correct setting for a given stage is accomplished, it is transferred to the control console ; the contact drum is turned manually to a next stage and the process repeated. With the setting completed, the actual test run is fully automatic ; when the contact drum revolves automatically from one stage to the next. The dynamometer with its large reading scale, the contact drum and the remote control box are clearly identifiable in Figs. 7, 9 and 14.

Apart from the above elements, limit switches for safety, and those for cut-out on failure of the specimen, the electrical control units are housed in the control console. Ease of operation is enhanced by numerous indicators and signal lamps. On the vertical face of the console a row of eight predetermined counters can be seen (second row from top, Fig. 6) ; these can be set to any desired number up to 990,000, according to the numbers of cycles to be applied at each of the programme stages. The counter of the operating stage works back to zero from the selected number, and in doing so stores the counts in one of the storage counters (top

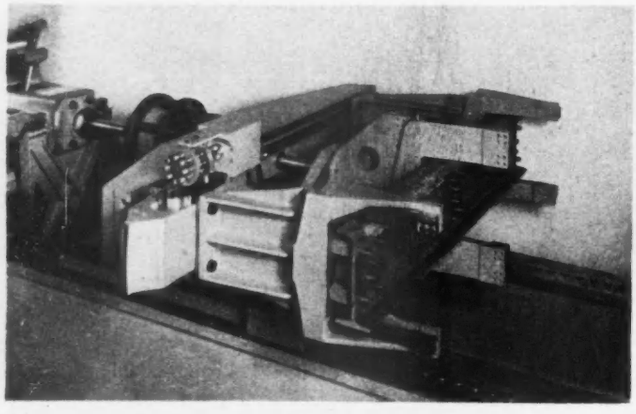


Fig. 13—Bending attachment for three-point loading

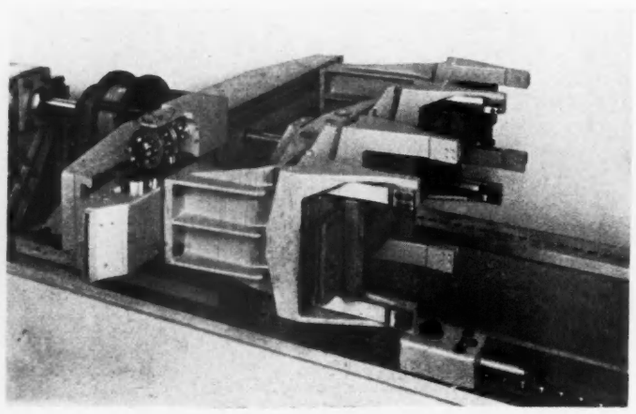


Fig. 14—Bending attachment for four-point loading

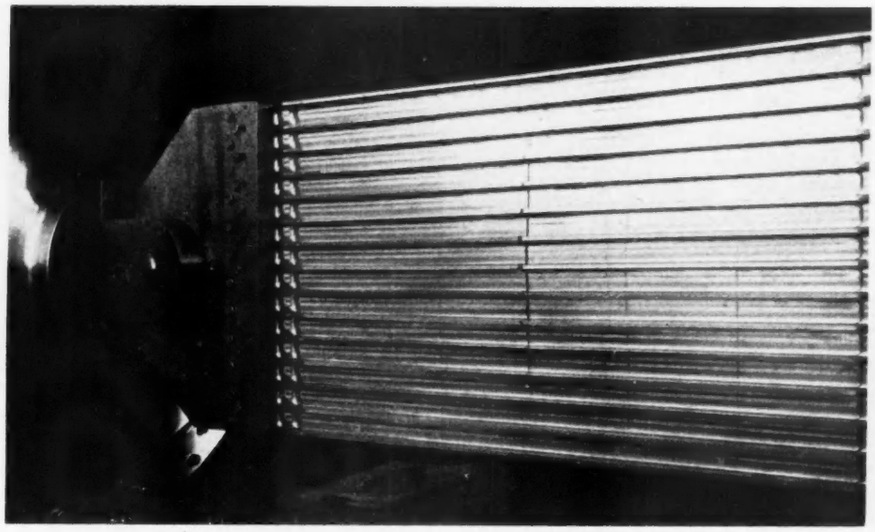


Fig. 15—Integrally stiffened panel in the state of advanced crack propagation. The centre rib has been cut to simulate "damage," and the crack is opened up under full load

left and right). When the operating counter reaches zero it switches to the next stage, but the exhausted counter is first reset by the storage counter, i.e. the storage counter brings the figures back to the predetermined number so that the predetermined counter is ready when its turn comes again.

Separate totaliser counters for the fast and slow drives are provided as well as a resetting programme cycle counter. These are situated on the inclined face of the control console. The programme cycle counter can be used also for stopping the machine after a predetermined number of programme cycles have been applied.

Some Typical Applications of the Machine

At Bristol the initial tests were made on structural specimens for the comparison of the spectrum results with constant amplitude results for which a large amount of data already existed. The specimen in Fig. 7 is a typical skin-stringer joint of a lower wing surface. It is a design of high static redundancy for which "fail-safe" properties[2] are claimed. In contrast, the specimen shown in Fig. 9 is an older type of wing joint, in which the spar boom carries concentrated loads. In each case the appropriate flight spectrum was used, consisting of gust loading applied about the constant mean load of steady level flight and the take-off and landing loads at a different mean load. As a detailed description of the comparison of results obtained cannot be attempted here, only the salient features will be mentioned: first, the spectrum lives were shorter than constant amplitude lives; secondly, the location and mode of failure were different; thirdly, less scatter was experienced with spectrum results than with those at constant amplitude. Although these findings must not be generalised, they may hold in the majority of cases, and they confirm also prior work done.[6]

Apart from the above type of work, which, with numerous variants, will, no doubt, become the routine, the machine can be used for research work with either increasing or decreasing programme stages. Thus, the Prot-type of test [4] and fundamental cumulative damage studies will be facilitated. By using one stage only, the machine can be employed for S–N curve determination[5], with the added benefit of having two speed ranges at disposal, so that the slow drive can be used with advantage for determining the fatigue strength at high stress; as the number of cycles to failure is small, the time taken is tolerable and the results more accurate than with high-speed testing. Equally, when dealing with rubber[7] and plastics the slow drive is used (except perhaps for the lowest stress level) so as to avoid heating up of the specimen. It is with such materials, or with springs[8] that the large deflection amplitudes provided for in the design of the machine are most useful.

Another interesting application concerns the study of crack propagation. Fig. 16 shows an integrally stiffened panel of 75-S material, the central stiffener of which was cut to represent damage and a "high" and a "low" tensile stress level applied at a constant cycle ratio, i.e. 8000 ± 5000 lb per square inch for 600 cycles alternated with 8000 ± 7500 lb per square inch for 200 cycles. To save testing time, only the higher of these two stress levels was applied with the fast drive during the initial low rate of crack propagation; when the crack propagation rate increased, the slow drive was used for applying the mixed loading in the manner described. Thus a very accurate plot of crack length against cycles could be obtained. The resulting fracture surface (Fig. 17) is very revealing as it shows distinct concentric bands due to the different applied stress levels, being a simple proof for different mechanism of damage as a function of stress level. Similar patterns are obtained under multi-level programmes,[6] the evaluation of which enables the determination to be made of crack propagation rates in components where the crack is not visible until it reaches the surface.

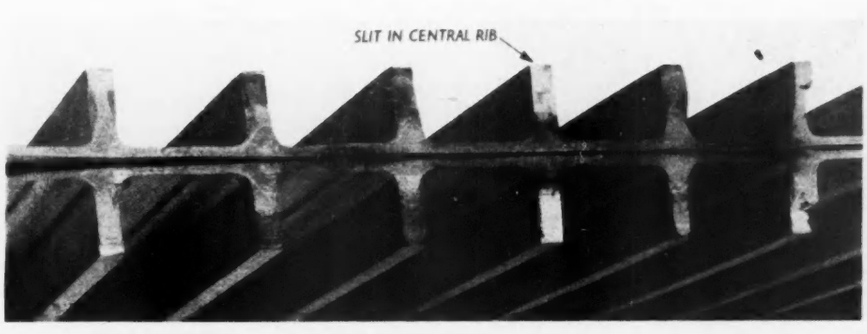


Fig. 16—Fracture surface of specimen shown in Fig. 15. The pattern of concentric bands is due to different load levels

Concluding Remarks

A major criterion of realistic testing is whether test failures are similar to those occurring in service. In this respect, too, programme loading represents a definite advance over the conventional technique of testing. Thus, based on programme tests, improvements in detail design can be made that are relevant to service behaviour. It goes without saying that design modifications based on unrepresentative testing techniques may be meaningless from the service point of view. Another criterion is that of economy: fewer specimens and less testing time are needed for obtaining spectrum lives than are needed for the determination of the S–N curve.

Although in other industries fatigue failures have been less troublesome and not so fatal as in the aircraft industry, the pursuit of weight economy and high utilisation is leading towards lower realisable structural and mechanical safety margins in, for example, the motor industry,[6, 8] the railways,[7] and even bridge building,[9] which call for test methods as realistic as those which are being found necessary for aircraft.

The short list of references included in this paper was selected with particular regard to further bibliography contained in the papers quoted. These could open up the subject to the reader who wishes to pursue it further.

Acknowledgments

The author wishes to thank Bristol Aircraft, Ltd., for permission to publish this paper and for the use of works photographs. Opinions expressed are purely personal. Credit is due to C. Schenck G.m.b.H., for photographs shown in Figs. 10, 13 and 14.

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Notable British Locomotives of 1908

By E. C. POULTNEY, O.B.E.

No. II—(*Concluded from page 767, November 14*)

L. and Y. Four-Cylinder Engines

THE large six coupled engines of the 4–6–0 type with four simple expansion cylinders were a complete contrast with previous Horwich designs for passenger services, for which they were specially built, though Geo. Hughes, when he read his paper entitled "Locomotives Designed and Built at Horwich," before the Institution of Mechanical Engineers in 1909, said that when designing these new engines he also had in mind the working of fast freight trains. Hitherto, L. and Y. express passenger traffic had been mainly worked by 4–4–0 or 4–4–2 type locomotives designed by J. A. F. Aspinall, later Sir John Aspinall, first built in 1891 and 1899 respectively, and distinguished by having coupled wheels of as much as 87in diameter, compared with only 75in for the new four-cylinder engines.

The use of such large driving wheels as 87in for a line abounding in steep gradients is a point that has been remarked upon. But Aspinall is said to have maintained that the engines with the large wheels compared with others previously built with smaller, 72in, diameter wheels, though otherwise of the same type and dimensions, were more economical in steam consumption and that, owing to the reduced speed in revolutions per minute at equal speeds in miles per hour, mean effective pressures were improved. On this latter point it is of interest to note that E. L. Ahrons stated that in his experience the 4–4–0 engines with the larger wheels made quite as good time climbing up from Manchester to Walkden with the Manchester and Liverpool expresses as those of the same type with 72in wheels. This is a difficult length of line with a maximum rising grade of 1 in 84. The fact that the large wheeled engines were found to handle the traffic as expeditiously as those having the smaller driving wheels is interesting, particularly when their relative tractive efforts per pound of mean effective pressure in the cylinders is considered, which, for 87in wheels is 97 lb, while for the engines with the smaller, 72in, drivers it is 117 lb, representing an increase of 22 per cent. Further, it may be of interest to note that each of these classes had the same working steam pressure of 160 lb per square inch and that, in respect to the size of the boilers, the heating surfaces were very closely the same and the grate areas identical; however, the relative proportions of the 4–4–0 and 4–4–2 and the new 4–6–0 engines are given in the following Table II.

Adjacent inside and outside crank pins were on opposite centres and the two pairs of cranks were at 90 deg. to each other. Two sets of Joy's valve gear applied to the inside motion operated the four slide valves, those for the inside cylinders direct, and the outside valves by means of rocking levers connecting with the outside valve spindles at the back of the cylinders instead of at the front, as in the case of the G.W.R. four-cylinder locomotives.

A good feature of the Joy's gear as applied

TABLE II—*Lancashire and Yorkshire Railway—Dimensions of Passenger Locomotives, 1888–1908*

Locomotive No.	1	2	3	4	5	6
Type	4-4-0	4-4-0	4-4-2	4-4-0	4-4-0	4-6-0
Cylinders :						
Number	2	2	2	2	2	4
Diameter and stroke, inches	18×26	18×26	19×26	18×26	20×26	16×26
Wheels, coupled :						
Diameter, inches	78	87	87	87	87	75
Boiler :						
Type	Round top	Round top	Belpaire	Belpaire	Round top	Belpaire
Steam pressure, pounds per square inch	160	160	175	180	180	180
Heating surfaces, square feet :						
Tubes	1121·3	1108·7	1877·0	1081·0	779·09	2317·0
Firebox	107·7	107·7	175·8	107·0	108·18	190·0
Total	1229·0	1216·4	2052·8	1188·0	887·27	2507·0
Superheater	—	—	—	—	209·90	—
Combined	—	—	—	—	1097·17	—
Grate area, square feet	18·75	18·75	26·0	18·75	18·75	27·0
Weights, tons :						
On coupled wheels	29·5	31·0	35·0	33·55	32·35	59·012
Engine	43·3	44·16	58·75	47·85	48·75	78·075
Engine and tender	69·42	70·28	89·4	73·97	74·87	108·73
Rated tractive force, pounds	14,670	13,150	16,030	14,830	18,280	27,150
Tractive force/grate area	782	702	616	791	974	1048
Factor of adhesion	4·5	5·28	4·89	5·06	3·96	4·87

Notes: Locomotive No. 4 is No. 2 rebuilt with Belpaire boiler.
Locomotive No. 5 is No. 2 superheated (Walschaerts valve gear).
Locomotive No. 3, as originally designed in 1899 by Sir John Aspinall.
Locomotive No. 5, tubular heating surface includes superheater flue tubes.

Turning now to the new four-cylinder six coupled engines, Fig. 9, the comparatively large boiler of the Belpaire pattern claims attention. The total heating surfaces, all evaporative, a superheater not being fitted, amounted to 2507 square feet and the area of the grate, 27 square feet. The working steam pressure of 180 lb per square inch may perhaps be considered low and, indeed, was, when compared with Churchward's standard of 225 lb per square inch. This lower pressure was, however, preferred by Hughes on account, it is said, of boiler maintenance difficulties, held to be greater with higher steam pressures. The four cylinders were arranged in much the same manner as the G.W.R. "Star" class, but with the inside pair not quite so far in advance of those outside, thus unlike the "Star" class; the connecting rods for the middle cylinders were considerably shorter than those outside. The drive was divided, the two inside cylinders driving the leading coupled axle through the medium of a built-up crank axle, and the outside driving the intermediate wheels through crank pins in the wheel centres.

to these engines was the fitting of a substantial guide in the form of a crosshead sliding in guides where the radius rods were pin-connected with the valve spindles, which were, therefore, not subjected to the bending action due to the upward or downward thrust from the radius rods, at times noticeable with this valve gear. The writer remembers when the L.N.W.R. "Precursor" class, with Joy's gear, first came out this bending action on the valve spindles was very noticeable when the engines were starting in full gear and more especially if the front port happened to be fully open, which, in combination with the fairly long full gear travel of 5¼in caused the valve spindles to project some distance from the cylinders. Later, guides were fitted to support the spindles at the radius rod connections, which seemed an improvement.

The revolving masses between the frames were balanced by weights, formed as extensions of the cranks, and those for the outside motion by weights in the wheel centres, as usual. When Hughes read his 1909 paper, he described the balancing system adopted

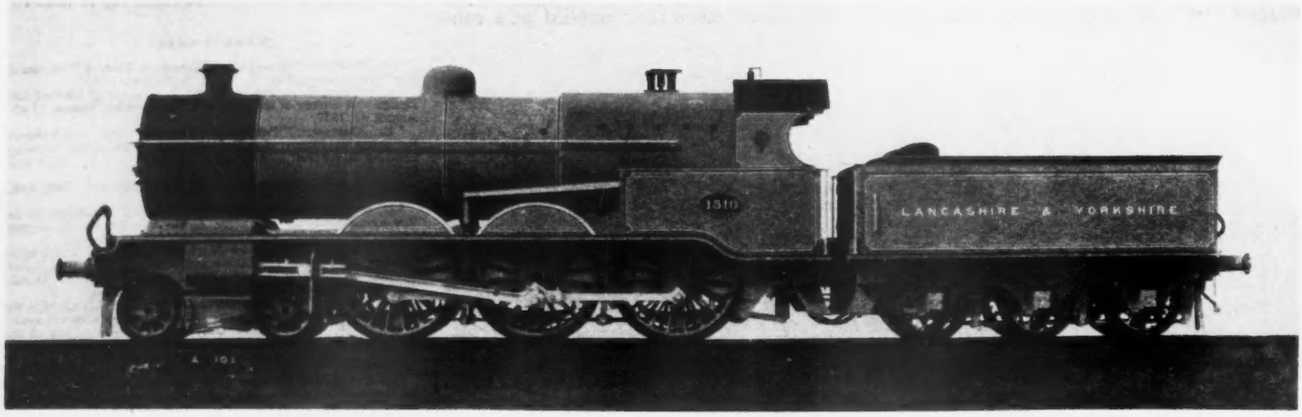


Fig. 9—Four-cylinder 4–6–0 type passenger engine—L. and Y.R.

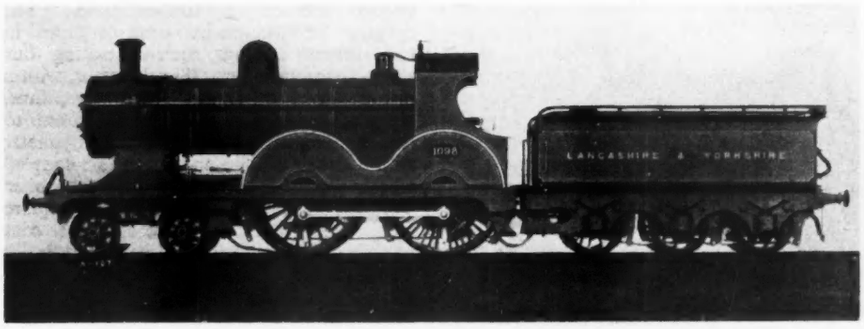


Fig. 10—Passenger engine 4-4-0 type superheater conversion—L. and Y.R.

and stated that " the reciprocating parts on the inside of the frames moving in the opposite direction to the outside counteract each other and the engine is balanced, so far as reciprocating parts are concerned except for a horizontal swaying couple, which is inconsiderable."§ Unfortunately, this method of balancing was not altogether a success, the " swaying couple " being far from inconsiderable, so much so that these engines were said to be very rough to ride on.

In their original form, these four-cylinder engines do not seem to have been entirely successful, and, later, were reconstructed and altered rather considerably in many respects, notably by being fitted with superheaters, new cylinders with piston valves, and Walschaerts valve gear applied to the outside cylinders took the place of Joy's gear, no doubt a better arrangement.

Superheating Developments

The fitting of superheaters of the Schmidt type to Horwich locomotives was first undertaken in 1906, as previously chronicled in these historical notes. Following these initial experiments with the standard 0-6-0 type freight locomotives, developments in 1908 involved the fitting of superheaters to passenger engines of the 4-4-0 type (Fig. 10), formerly built in the first instance by J. A. F. Aspinall in 1891—that is to say, they were those having the large diameter driving wheels which for many years had done excellent work on the line. When superheated, they were considerably modified in many respects by the fitting of new cylinders with piston valves and a boiler with a cylindrical smokebox and drumhead pattern of tube plate carried on a saddle in place of the original built-up type. As a result of these modifications, the boiler centre line was increased in height above the rails from 7ft 9in to 8ft 7½in, which, together with the other alterations, considerably changed their appearance. Beyond the fitting of piston valves in lieu of slide valves, some of these superheated engines were given Walschaerts valve gear in place of the old standard Joy's gear, and the photograph of engine No. 1089, now reproduced, is one of those equipped with the new valve gear. The principal dimensions of these superheated engines are included in Table II.

§ For a discussion on the balancing of the L. and Y. four-cylinder engine, see " The Balancing of Locomotives," J. Dunlop, *The Mechanical Engineer*, March 8, 1912.

Worsdell's Four-Coupled Passenger Locomotives

Wilson Worsdell's 4-4-0 type express passenger engines for the North Eastern (Fig. 11) were a development of a previous design built originally in 1900, but of enhanced size and power on account of their larger boilers and increased steam pressure, which was raised from 200 lb to 225 lb per square inch. The cylinders, 19in diameter, with a stroke of 26in, and the 82in driving wheels were a repeat of the earlier class, but the higher steam pressure increased the rated tractive force from 19,400 lb to 21,900 lb. The larger boiler, with 1737 square feet of heating surface and 27 square feet of grate area, also constituted an advance compared with those of the earlier locomotives, which had 1527 square feet of heating surface and a smaller grate area of 20 square feet. In general design, the new engines complied with recent practice on the North Eastern; thus, the cylinders were of a design due to W. M. Smith, of the Gateshead Works, embracing piston valves in valve chambers either above or below the cylinders and so arranged with respect to the cylinder axis that the valves could be operated direct by Stephenson's valve gear. This cylinder design, together with piston valves, was, as previously mentioned, also taken up by S. W. Johnson, of the Midland Railway,‖ and was fully described in a paper read by W. M. Smith before the Institution of Mechanical Engineers in 1902. In the case of the new 4-4-0 engines, the piston valves, 10in diameter, were arranged above the cylinders, operated direct by Stephenson's gear. In common with North Eastern practice, the crank axles were of the pattern due to T. W. Worsdell, having circular crank webs which considerably simplified machining, which could be completely finished in a lathe. The large boilers were possibly the principal feature of these engines and were, in general, very like those used for W. Worsdell's class V " Atlantics " of 1903, reduced in the length of the barrel to suit the different wheel arrangement; the firebox, however, remained the same length, namely, 9ft, thus giving the same grate area of 27 square feet. The height of the firebox was, however, modified in order to permit of its being carried over the trailing coupled axle, for which purpose also the boiler centre line was raised to 8ft 11in above the rail level. The boiler barrel diameter was 5ft 6in, as for the " Atlantic " design, the reduced length being 11ft 6in, compared with 16ft 8½in. The barrel sections were butt jointed with outer circular welt strips as before.

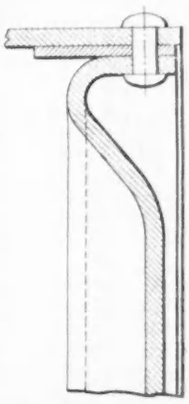


Fig. 12—Back plate with return flange used for North Eastern locomotive boilers

A further uncommon feature of this boiler and others of the larger modern designs on the North Eastern was the method followed for riveting the boiler back plate into the outer wrapper (Fig. 12). The accompanying sketch will show how this was done by forming the back plate with a return flange which facilitated machine riveting. The thin plate inserted between the wrapper and back plates was found necessary to prevent grooving of the wrapper inside at a point in the vicinity of the inner rounded part of the back plate. This form of construction, used extensively on the North Eastern, was originated by F. W. Webb at Crewe, and remained standard practice on the London and North Western for many years.

These large 4-4-0 engines were noteworthy on account of their weight, which totalled 59·5 tons, of which 42 tons rested on the coupled wheels. While the L.N.W.R. " Precursor " class, also of the 4-4-0 type, scaled 59·75 tons and was, therefore, the heavier of the two, the N.E.R. engines with the 45·2 ton tenders, making a locomotive weight in working order of 105·1 tons, were the heaviest of the 4-4-0 wheel classification with six-wheeled tenders in the country. The tenders were remarkable for their high water and coal capacities of 4125 gallons and 5 tons respectively.

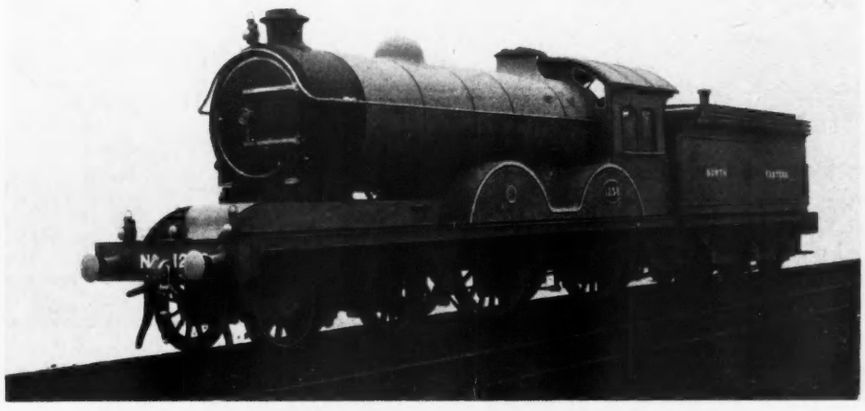


Fig. 11—W. Worsdell's four-coupled 4-4-0 engine for passenger services—N.E.R.

‖ " Notable Locomotives of 1904," The Engineer, October 8, 1954.

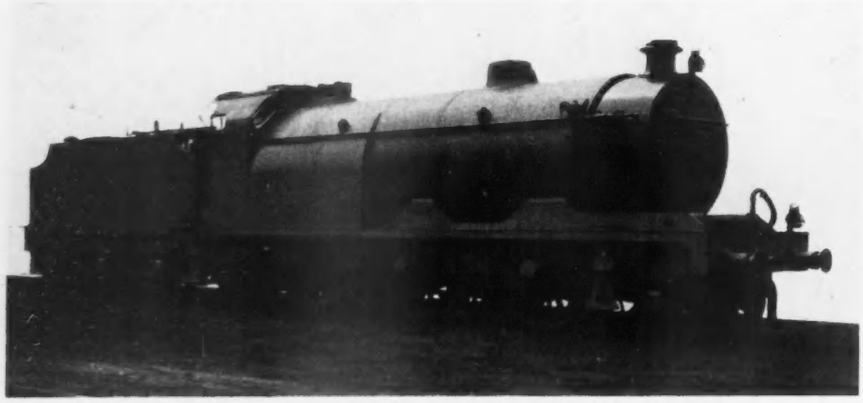


Fig. 13—The " Paget " locomotive—M.R.

The principal dimensions of these particularly handsome locomotives were:

North-Eastern 4-4-0 Passenger Engines

" R " Class

Cylinders :	
Diameter and stroke, in	19 × 26
Driving wheels, diameter, in	82
Heating surfaces, square feet :	
Tubes	1579
Firebox	158
Total	1737
Grate area, square feet	27
Steam pressure, lb per square inch	225
Engine weight, tons :	
On drivers	42
Total	59·5
Engine and tender	105·1
Rated tractive force, lb	21,900
Factor of adhesion	4·3
Tractive effort/grate area	810

THE " PAGET " LOCOMOTIVE

A remarkable locomotive (Figs. 13 and 14), built experimentally at the Derby Works of the Midland Railway to the designs of Cecil Paget, later Sir Cecil Paget, at the time the Works Manager under R. M. Deeley, Locomotive Superintendent, was an entirely revolutionary conception, embracing, as it did, many innovations foreign to accepted practice. According to E. L. Ahrons, the object of the designer was to obtain " good balancing with no reversal of thrust in the moving parts, while the steam distribution was controlled by rotary valves giving quick opening and release."[¶] Though not a success, it was, nevertheless, certainly interesting and, in fact, ingenious in its conception, so that, though it cannot be said to have influenced subsequent developments in British practice, no account of the more noteworthy locomotives built in 1908 would be complete without some reference being made to this unique locomotive. For many years the special features embodied in its construction remained unknown, at least generally, and, as a matter of fact, it is probable that it was not until Ahrons' description appeared that much, if anything, had been made known concerning the construction of this engine. More recently, *The Railway Gazette* of November 2, 1945, published an excellent description, together with numerous drawings of the details, including also a general arrangement, which is now reproduced by permission of the Editor. This clearly shows the arrangement of the cylinders and how the drive was divided between the coupled axles. The cylinders were, it will be noted, contained in two separate castings, each containing four single-acting cylinders, 18in diameter, with a piston stroke of 12in. There were, thus, eight cylinders, single acting, equivalent to two double-acting cylinders 18in diameter with a stroke of 24in and, as the six-coupled wheels were 64in diameter and the boiler working steam pressure 180 lb per square inch, the rated tractive force at 85 per cent of the boiler pressure would be 18,574 lb.

The centre axle had four cranks, taking the drive from four cylinders, two in the front cylinder casting, spaced at 19in centres, and two in the rear casting, spaced at 44in centres.

The leading and trailing axles each had two cranks and were driven by two cylinders, spaced at 44in and 19in centres respectively. As the cylinder castings had a width of 5ft 6½in, the main frames were outside the coupled wheels to give the required distance between to accommodate the cylinder castings. The coupling rods had, in consequence, outside cranks. Beyond the arrangement of the cylinders, a further distinctive feature in the design was the use of rotating valves for the steam distribution in the cylinders, which, due to their arrangement with respect to each other, was such that two valves only were required for all eight cylinders, there being, therefore, one valve for each set of four. The rotary valves presented the real difficulty and, apparently, gave considerable trouble which was never properly overcome. The valves were operated by gears so arranged that their direction of rotation could be reversed, thus permitting the locomotive to run forwards or backwards as required. The primary drive for these gear assemblies was by means of a layshaft positioned transversely at the rear end of the engine and fitted with two cranks at right angles to each other, which were connected by rods to the main coupling rods. Each valve revolved in a sleeve having two sets of ports in it, four on each side, diametrically opposite each other, one set of ports for supplying steam to the right hand and one set for the left hand

¶ *The British Steam Locomotive*, 1825–1925. E. L. Ahrons. Page 343.

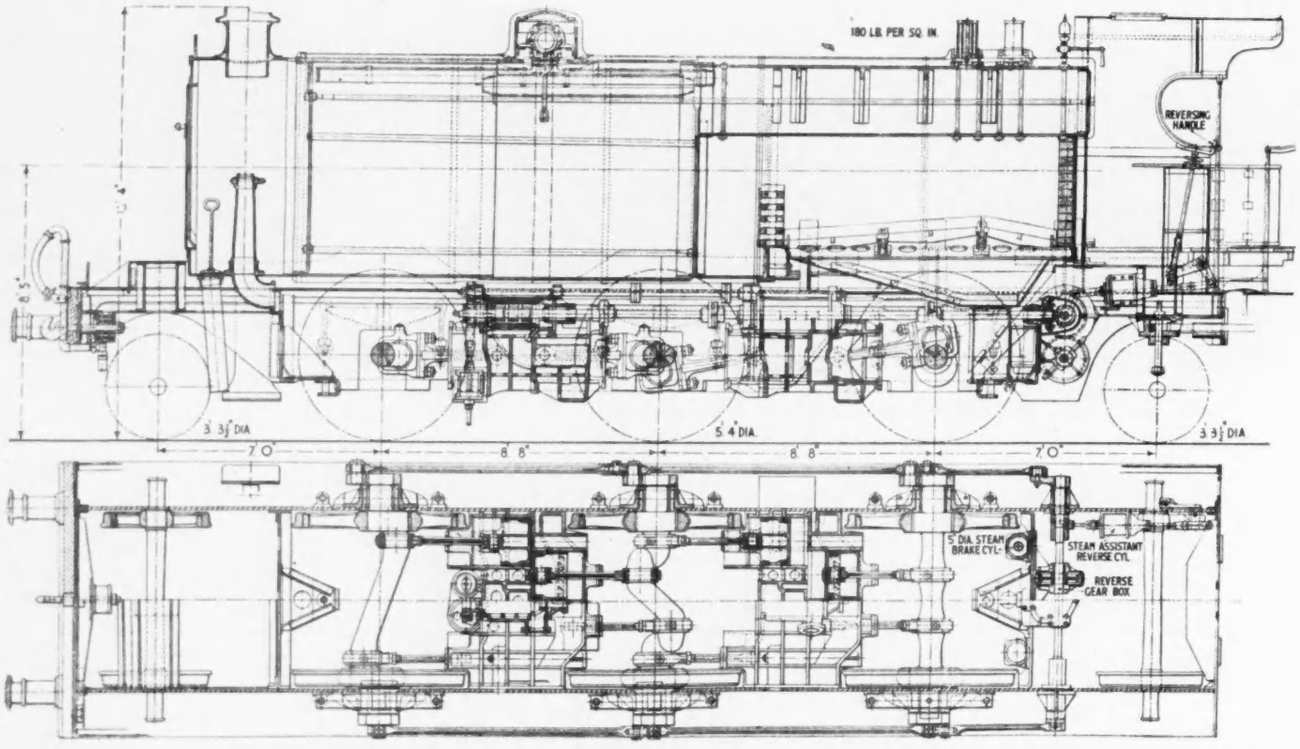


Fig. 14—The " Paget " locomotive. General arrangement drawings—M.R.

pair of cylinders. Thus, on turning this sleeve round in a direction opposite to that in which the valve was rotating, the number of ports open to steam could be varied according to the cut-off required. The sequence of port openings in relation to the rates of admission was as follows :

All ports open, cut-off	75 per cent
Three ports open, cut-off	59 per cent
Two ports open, cut-off	42 per cent
One port open, cut-off	25·5 per cent

It must be understood that the admission steam was supplied through the centre of the cylindrical rotating valve, which had a port running longitudinally in its periphery. The rotation of the ported sleeve for alteration of cut-off caused the ports to be successively blanked off by the edge of the portway leading to the cylinders. It will, therefore, be evident that shortening the rate of admission reduced at the same time the port area available for admission steam, which was in a measure compensated for by making the last port in the sleeve, being the one used at the earliest rate of cut-off, rather wider than the other three. This ingenious and, in fact, novel arrangement, unfortunately, gave considerable trouble by seizing up on more than one occasion ; finally, recurring difficulties of this kind seemed to have proved sufficient to condemn the locomotive. Some years later, about 1912, the Pennsylvania Railway, when developing the design of high-powered " Atlantic " type locomotives, tried a form of rotary valve and special valve gear in an effort to find something better than piston valves, but, apparently, without satisfactory results. The Paget valve is certainly of some interest and perhaps in this connection mention may be made of an interesting and successful form of piston valve designed to provide a variable expansion device fitted to the h.p. cylinders of multi-stage expansion engines by Belliss and Morcom, Ltd. In this arrangement steam admission takes place between the valve heads exhausting at the ends and the admission edges of the valve, and the corresponding edges of the ports in the valve chamber liner are set at an angle of 45 deg. to the horizontal, with the result that a partial rotation of the valve on its spindle (the liner remaining fixed) alters the effective steam laps, so altering the rate of cut-off in the cylinder. The partial rotation of the valve in its liner is controlled by the governor. While this is not a constantly rotating valve, it is possibly of interest to bring this ingenious piston valve application to mind. The rotating valves of the " Paget " locomotive only controlled the admission steam, exhaust being by means of ports in the cylinder barrels uncovered by the pistons at about the end of the stroke after the manner of the Stumpf uniflow system. The rotary valves did not, therefore, control the point of release, as suggested by Ahrons.

The pistons, of the trunk pattern, were fitted with Rowans packing rings, which, it may be mentioned, are also used by Belliss and Morcom for the l.p. cylinders of their well-known " quick revolution " engines of the multi-stage expansion types, to which reference has previously been made. The " Paget " boiler had a barrel section, 6ft 8in diameter inside at the largest part, and the length between the tube plates was 12ft. The tubes, 2½in outside diameter, had internal fins. The firebox was, however, the novel feature ; it was of very large size, the grate area being as much as 55 square feet. The inside was lined with firebricks for the sides and rear wall, which had two firedoors. At the front of the grate there was a brick wall so placed that between it and the tube plate there was a space of 2ft 3in, which formed a combustion chamber. The roof of the firebox was unlined, so providing heating surface. The firebox roof was direct stayed to the semi-circular shell, but the usual firebox side stays were, of course, dispensed with. The foregoing is offered by way of a brief general description of this attempt to displace Stephenson's basic design, as exemplified by his engine " Northumbrian " of 1830. Of it this much can be said : it was an interesting conception which might conceivably have been further developed had circumstances then been more favourable than are said to have been the case.

Some dimensions of the " Paget " locomotive may be of interest and are given as follows :

The " Paget " Locomotive—Dimensions

2-6-2 Type

Cylinders :		
Number	8	
Type	Single Acting (Uniflow)	
Size, diameter and stroke, in	18 × 12	
Boiler steam pressure, lb per square inch ...	180	
Wheels, diameter, in :		
Leading and trailing trucks	39½	
Coupled	64	
Wheelbase:	ft	in
Leading truck to 1st drivers	7	0
1st to 2nd drivers	8	8
2nd to 3rd drivers	8	8
3rd drivers to trailing truck	7	0
Total engine	31	4
Engine and tender	62	0½
Weight, tons :		
On drivers	56	
Engine	80	
Engine and tender	122·9	
Rated tractive force, lb	18,574	
Factor of adhesion	6·74	

L.S.W.R. Four-Cylinder Locomotives

Following the two different designs of four-cylinder six-coupled passenger engines built at Nine Elms to D. Drummond's designs in 1905 and 1907, which have already received attention in these articles, a further series of generally very similar locomotives appeared in 1908, as illustrated by the photograph of engine No. 453 (Fig. 15). The new engine, of which five were put into traffic, while in many respects resembling those previously built differed principally by having a smaller boiler with 1920 square feet of heating surface, compared with 2727 square feet, and cylinders reduced in size from 16½in by 26in and 16in by 26in for the engines of 1905 and 1907, respectively, to 15in by 26in.

As in the case of the earlier series, the cylinders were arranged two inside, the drive being taken by the leading pair of wheels through the medium of a built-up crank axle, and the outside pair connected as before with the intermediate driving wheels. Like the 1907 engines, the outside cylinders had piston valves, the valve chambers being on the top of the cylinders ; also, as before, Walschaerts valve gear operated the valves, while the inside cylinders had, like the other engines, slide valves and Stephenson's gear.

The boilers were, in general design, like those used for the two previous classes, but the barrel portion was smaller in diameter, being 4ft 9½in, compared with 5ft 6in ; the length was, however, the same, as was also the distance between the tube plates. As a result of the smaller barrel diameter, the tubes, 1¾in outside diameter, were reduced in number from 340 to 247 with a corresponding reduction in the tubular heating surfaces to 1580 square feet as against 2210 square feet.

The small barrel diameter reduced the height of the firebox, so that, though it was of the same length and width, thus providing the same grate area of 31·5 square feet, the heating surfaces of the firebox proper became 140 square feet as compared with 160 square feet. In common with Drummond's practice, cross water tubes were fitted in the firebox in two nests, each of forty-two 2¾in diameter tubes, giving 200 square feet of additional heating surface in the firebox. The former working steam pressure of 175 lb per square inch was retained, as was also the diameter of the coupled wheels of 72in. Due to the smaller boiler, these new engines were lighter in weight than those built previously, the difference being 70·95 tons, compared with 73·0 tons, and 76·65 tons for the 1905 and 1907 series respectively.

The large eight-wheeled double bogie tenders, fitted with Drummond's feed water heating equipment, were in all respects a standard for Dummond's large main line locomotives, and weighed, when loaded with 4500 gallons of water and 5 tons of coal, as much as 49 tons. The leading dimensions of these engines are tabulated below :

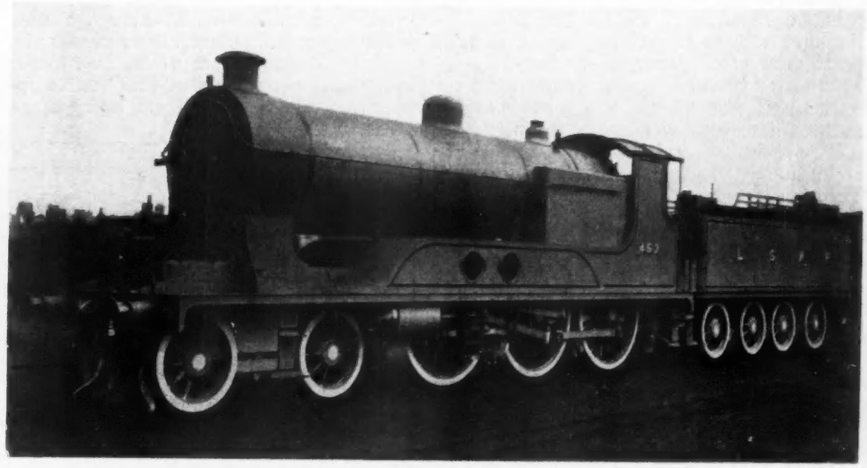


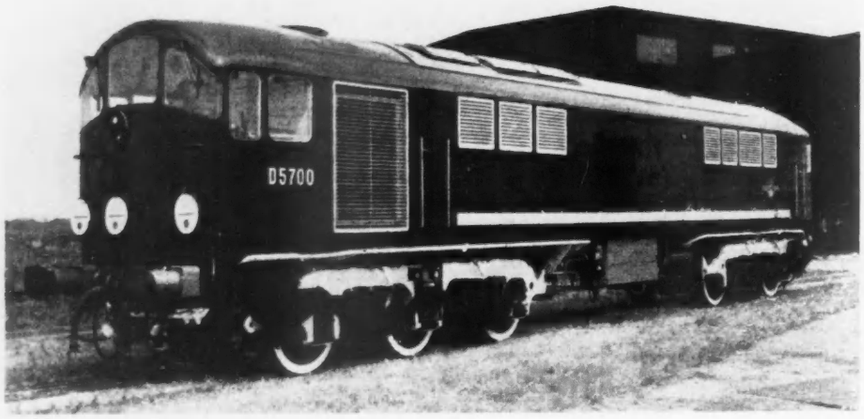
Fig. 15—Four-cylinder 4-6-0 passenger locomotive. D. Drummond—L. and S.W.R.

L.S.W.R. Four-Cylinder Locomotives

Cylinders	Four
Diameter and stroke, in	15 × 26
Driving wheels, diameter, in	72
Heating surfaces, square feet :	
Tubes	1580
Firebox	140
Cross water tubes	200
Total	1920
Grate area, square feet	31·5
Steam pressure, lb per square inch	175
Engine weight, tons :	
On drivers	50·65
Total	70·95
Tender	49·00
Total locomotive	119·95
Rated tractive force, lb	24,200

1200 H.P. Diesel-Electric Locomotives for British Railways

Twenty 1200 h.p. diesel-electric locomotives being supplied to British Railways' London Midland Region by the Metropolitan-Vickers Electrical Company, Ltd., have the somewhat unusual axle arrangement of C_0-B_0. With this arrangement the weight of the heaviest part of the power equipment—the Crossley eight-cylinder diesel engine—is carried at the three-axle bogie end and the total weight of 97 tons is almost evenly distributed over the five axles.



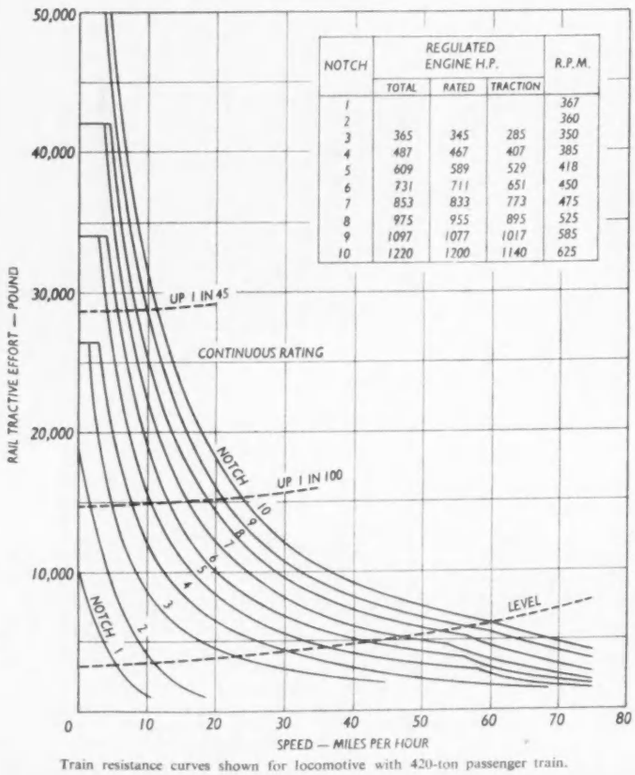
TWENTY 1200 h.p. diesel-electric locomotives for mixed traffic duties on the Midland Division of the London Midland Region are being built for the British Transport Commission by the Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, and the first five of these locomotives have been delivered. The mechanical parts of these locomotives are being supplied by Metropolitan-Vickers—Beyer Peacock, Ltd., the engines by Crossley Bros., Ltd., and the electrical equipment by Metropolitan-Vickers Electrical Company, Ltd.

As can be seen from the illustration above the new locomotives are of C_0-B_0 type and they are so designed that up to three locomotives can be driven in multiple. The principal data of the locomotives are given in the table below. Multiple-unit operation of these locomotives with others now being delivered under the modernisation scheme and fitted with electrical equipment by The General Electric Company, Ltd., and British Traction, Ltd., has been arranged by co-operation between the three companies.

Principal Data of 1200 H.P. Locomotives

Wheel arrangement	C_0-B_0
Total weight in working order	97 tons
Length overall	56ft 7½in
Total wheelbase	42ft 7in
Bogie wheelbase	12ft 1½in (C_0) and 8ft 6in (B_0)
Distance between pivot centres	32ft 4in
Width overall	9ft 2½in
Height overall	12ft 8¾in
Wheel diameter	39½in
Traction motor gear ratio	15 : 67
Engine continuously rated h.p.	1200 h.p. at 625 r.p.m.
Maximum tractive effort at rail	50,000 lb
Continuous tractive effort at rail	25,000 lb at 13·5 m.p.h.
Maximum service speed	75 m.p.h.
Minimum curve radius	3½ chains
Fuel oil capacity (engine and boiler)	510 gallons
Water capacity for boiler	600 gallons
Steam capacity of boiler	1500 lb per hour
Brakes	Metcalfe/Oerlikon

As will be seen from the tractive effort speed diagram we reproduce, the maximum tractive effort is 50,000 lb, and the continuous tractive effort is 25,000 lb. It is these basic requirements that have led to the adoption of the five-axle, five-motor design. On notch 10 full power is available between 4·3 and 61 m.p.h., this range being covered by control of generator excitation up to about 25 m.p.h. and by traction motor field weakening thereafter, and the equipment is within the continuous rating at all speeds from 13·5 m.p.h. to the maximum speed of 75 m.p.h. At speeds below the full power range the tractive effort is automatically limited to the maximum by a current limit relay, while above the range the tractive effort decreases in accordance with the inherent characteristic of the motor at sensibly constant voltage.



NOTCH	REGULATED ENGINE H.P. TOTAL	RATED	TRACTION	R.P.M.
1				367
2				360
3	365	345	285	350
4	487	467	407	385
5	609	589	529	418
6	731	711	651	450
7	853	833	773	475
8	975	955	895	525
9	1097	1077	1017	585
10	1220	1200	1140	625

Train resistance curves shown for locomotive with 420-ton passenger train.

Performance of 1200 h.p. Type 2 diesel-electric locomotive with five motors connected permanently in parallel

Some indication of the hauling capability that these figures imply can be obtained from the fact that, on test runs before delivery, each single locomotive starts and accelerates to about 10 m.p.h. a 420-ton train (thirteen or fourteen bogie vehicles) on a gradient of 1 in 42 ; the balancing speed on the level with this weight of train is 60 m.p.h.

Mechanical Structure

The underframe, carlines, cantrail, floor and body sheeting of the locomotive form a complete welded structure designed to give maximum strength with minimum material. The underframe is made up largely of folded plate sections welded to form continuous longitudinal and transverse members with diagonal bracing, the transverse members being positioned at the load carrying points. The main fuel and boiler water tanks are incorporated within the underframe top and bottom plating, and in sections not used for tankage the traction motor air ducts are also built in. The body is divided by transverse bulkheads into four main compartments, namely, two driving cabs, an engine and radiator compartment and a generator and boiler compartment. Louvres are provided at the various air intake positions and panel " Air-Maze " filters are built into the engine air intake duct.

Sections of the roof are easily detachable for removal of the power unit, boiler, and auxiliary machines, while a number of smaller panels are provided for access to engine cylinder heads, fuel pumps and boiler fire tubes. End doors conceal a flexible gangway connection used when locomotives are operating in multiple.

Both three-axle and two-axle bogies have one-piece cast steel frames and in the orthodox body swing bolster suspension a flat body centre pivot fits into a "Ferobestos" lined cup on the bolster. The bolster is hung from the frame by swing links, of which there are eight on the three-axle and four on the two-axle bogies. Tractive effort and braking forces are exerted through renewable liners placed between the bogie transoms and the bolster. Springing is by the semi-equalising method, whereby beams span between the axles, and the bogie frame is supported on helical springs resting on these beams. The suspension includes " Metalastik" bonded rubber sandwiches interposed between the axlebox top and the equalising beams. "Ferobestos" pads are fitted in the

spring seats, and "Woodhead-Monroe" shock absorbers are arranged in parallel with the helical springs and between body and bogie frame.

The Hoffmann parallel roller bearing axleboxes which have pads for end location of the axle are oil lubricated and fitted with renewable manganese steel liners which slide on similar liners on the horn cheeks. Two of the boxes are fitted with special covers, one for a mileage counter and the other for a speedometer generator. All wheels are fitted with clasp brakes, operated through equalised brake rigging by three cylinders on the three-axle bogie and two cylinders on the two-axle bogie.

Power Equipment

The engine, forming the heaviest piece of power equipment, is mounted at the three-axle bogie end of the locomotive and is a Crossley two-stroke, eight-cylinder diesel which is continuously rated at 1200 h.p., 625 r.p.m., and at this speed has a one-hour rating of 1320 h.p. In this engine the use of the port-controlled loop scavenge system eliminates the necessity for cylinder head valves or operating gear. By the exhaust pulse pressure charging system on these engines some of the scavenge air that has passed through the cylinder into the exhaust manifold is forced back into the cylinder by the exhaust pressure pulse from an adjacent cylinder; this occurs at the instant of port closure, thus creating a positive pressure of about 10 lb per square inch at the commencement of compression. A three-lobe Roots scavenge blower is built into the forward end of the engine and delivers air to the manifolds through a pair of water-cooled air coolers. Primary balance of reciprocating parts is achieved by the provision of two reciprocating balance weights, one at the end of the engine and the other combined with the compressor.

Lubricating oil is supplied to the main bearings, the connecting rod large and small end bearings, the pistons, and other parts, by a gear pump chain-driven from an extension of the crankshaft. Electrically-driven water pumps are used and the main jacket-water pump motor also drives an auxiliary lubricating oil pump which circulates oil through a by-pass magnetic filter. The motor of the pump which circulates water for cooling the scavenge air and the lubricating oil, is also used to drive a crankcase exhaust fan which maintains the crankcase at a slight vacuum. The engine cooling equipment comprises a pair of Serck double-bank radiator panels mounted inside air ducting which connects openings in each body side to a motor-driven axial-flow fan mounted in the roof.

The main and auxiliary generators, both direct current machines, are of integral construction with the frame flange mounted on the end of the engine. The armatures are mounted on a common hollow shaft, which is coupled to the engine crankshaft at one end and carried on a single roller bearing at the other. The main generator supplies power to the five traction motors, the excitation being automatically controlled on eight of the ten master controller notches by the load regulator. It is an eight-pole generator with two separately excited field windings and a counter-compounded series winding which is also used when motoring from the battery for starting the engine. The continuous ratings to B.S. 173: 1941 are: 750V, 1070A at 625 r.p.m.; 475V, 1650A at 625 r.p.m. The auxiliary generator supplies power for all motor-driven auxiliaries, battery charging, control equipment, lighting, cab heating, main generator excitation and train heating boiler controls. It is separately excited from the battery and the output voltage is regulated to 110V d.c. over the full range of engine working speed and load. The continuous rating of this machine is 110V, 62kW at 625/400 r.p.m.

Both generators are self-ventilated by a fan, mounted on the shaft adjacent to the engine coupling flange; this fan draws air in at the commutator end of the machine and discharges into the engine compartment. Additionally, the generator and boiler compartment is pressurised, so that the air flow through the generators is considerably augmented without the provision of complex sheet metal air ducts.

The engine-generator set is resiliently mounted in the locomotive at three points, one below the engine base and one at each side of the generator. The mountings are of the "Dyna-Focal" type, whereby circular bonded rubber-to-metal sandwiches are placed on inclined faces, with axes focusing at a point vertically above the centre of gravity of the engine generator set. At the engine mounting, two such assemblies are used, one behind the other, and one assembly is used at each side of the generator. In order to retain the set in position in the case of violent buffing shocks or other mishaps, a rubber-covered buffer is built into the mounting assembly at the engine, and pillars fitted with a collar and pinnacle nut pass through clearance holes in the generator feet, thus positively limiting the movement of the set on the rubber mountings to ¼in in all directions.

Each of the five axles is fitted with a four-pole, series-wound, nose-suspended, axle-hung traction motor. The motor is supported on the axle by two white-metal-lined sleeve bearings and the resilient nose suspension consists of a link between bogie transom and motor frame. A similar link placed laterally between the bogie side frame and the motor frame prevents "side slog" of the motor on the axle and thus maintains the good riding qualities of the locomotive. The drive to the axle is through totally-enclosed single-reduction spur tooth gears with a ratio of 15 : 67, the gear wheel having torsional resilience between hub and rim.

The motors are force ventilated, with cooling air from blowers in the locomotive body, which deliver the air via ducting in the underframe and flexible rubber bellows between the underframe and the motors. The continuous rating of the motor is 475V, 330A, 180 h.p., 510 r.p.m., with 1250 cubic feet per minute ventilating air.

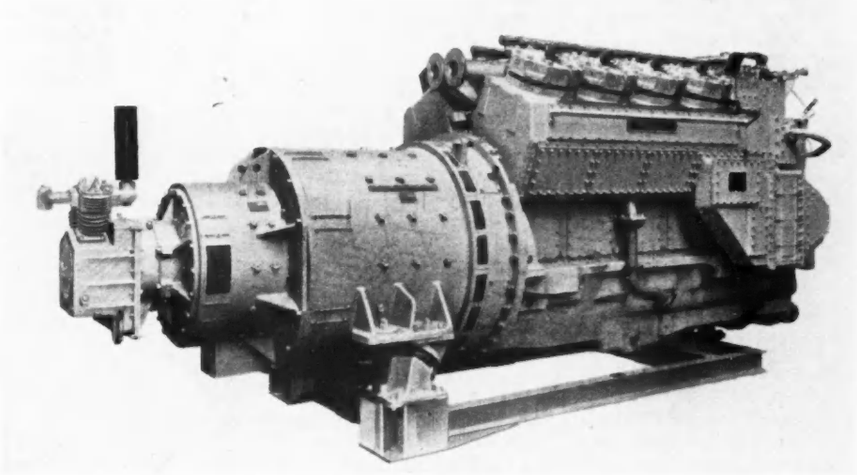
Air for operation of the locomotive brakes, electro-pneumatic control gear, horns, window wipers and sanding gear, is supplied by an engine-driven Worthington-Simpson compressor which is flange mounted to, and driven from, the auxiliary generator. Two motor-driven Westinghouse exhausters, provided for operation of the brakes on vacuum fitted rolling stock, have two speeds—the lower for maintenance of the vacuum and the higher for rapid brake release. Two Keith Blackman centrifugal fans, one at each end of the locomotive, supply cooling air to the traction motors. A Davidson axial-flow fan in the generator compartment is used for force-cooling the generator.

A Spanner oil-fired fire-tube train heating boiler has a capacity of 1500 lb of steam per hour. It is fitted with fully automatic controls and an "on/off" burner such that any steam demand within the capacity of the boiler can be met.

Control Equipment

Apart from the driving controls, the main items of control equipment are compactly arranged on three sides of a control cubicle, to which access is gained by a door opening into the gangway. The main generator supplies the five motors which are connected permanently in parallel. In each motor circuit there is an electro-pneumatic contactor and an overload relay, and a single electro-pneumatic drum reverser is used to reverse the motor field connections. Earth leakage protection is fitted, and provision is made for cutting out any one traction motor in the event of a defect, or all motors to facilitate testing of the engine. The master controller provides the driver with the means of selecting the direction of travel and the power at which the engine shall work. The selector handle has four positions, namely, forward, off, engine only and reverse, and the power wheel has ten "notches" to provide increments of engine power up to the maximum of 1200 h.p. on notch 10.

In notches 1 and 2 the engine runs at its idling speed, and the main generator is excited by the two stages of primary field strength. From notch 3 (corresponding to about 25 per cent traction horsepower) to notch 10 (full load) the engine speed and brake mean effective pressure are automatically set (by the engine speed regulator)



Power equipment consisting of diesel engine coupled to the main and auxiliary generators and an air compressor

to give increments of power, and this ensures that the engine operates at optimum conditions. Thereafter, adjustment of the electrical load to maintain the chosen conditions irrespective of track speed and train load is by the automatic load-regulating apparatus. This comprises a servo mechanism in which a hydraulic pilot valve, connected to the engine governor fuel lever, actuates a servo motor when displaced from the neutral position. The servo motor drives the camshaft of the load regulator, which adjusts the main generator secondary field excitation until the correct load is regained, when the governor returns the pilot valve to the neutral condition. When, with rising locomotive speed, the main generator field has been strengthened to the maximum voltage and minimum current condition, the load regulator weakens the fields of the traction motors in two successive stages, the sequence being reversed when speed falls. The use of a number of wire-wound resistances in parallel, each with an individual contact on the regulator for the traction-motor field-divert resistances, eliminates the need for contactors and enables the field strength to be changed gradually. A current limit relay is used to control the starting currents taken by the traction motors, a number of settings being provided such that graded steps of maximum starting tractive effort are available to the driver, thus reducing the risk of wheel slip to a minimum.

The various auxiliary motors are fed from the auxiliary generator through high rupturing capacity fuses and, where required, through electromagnetic contactors. A vibrating carbon-contact voltage regulator maintains the auxiliary generator voltage constant, and the control of battery charging is by a reverse current relay operating an electromagnetic contactor.

The locomotive is braked by " Metcalfe-Oerlikon " vacuum-controlled direct air brake system, manufactured by Davies and Metcalfe, Ltd. With this system the locomotive itself has air brakes, which are controlled either by a driver's direct air brake valve used when shunting or running light, or by a driver's vacuum brake valve when handling vacuum-fitted vehicles. In the latter case the rise and fall of vacuum attributable to the vacuum brake valve normally causes two triple valves, one for each bogie, to release or admit air to the 12in diameter brake cylinders, thus braking the locomotive as well as train. A foot switch at the driving position provides for the proportional locomotive brake application to be partially or fully released when required.

Thorpe Marsh 550MW Reheat Boiler

WE have received from International Combustion, Ltd., Derby, some further details of the 550MW boiler unit which this company is building for the power station projected by the Central Electricity Generating Board at Thorpe Marsh near Doncaster (THE ENGINEER, February 14, 1958, page 256).

It will be recalled that the C.E.G.B. proposes to establish on the River Don a 1100MW station of two 550MW generating sets with two boilers and it is the first of these boilers which is the subject of the following notes. Each boiler will require about 1,250,000 tons of coal per annum and it is proposed to take this coal from a wide area including the east Yorkshire coalfields and the East Midlands coalfields. This coal will have a gross calorific value of 8300–12,000 B.Th.U. per pound, an ash content of 6 to 30 or 40 per cent and a moisture content of 4 to 28 per cent. The operating conditions of the boiler are tabulated herewith.

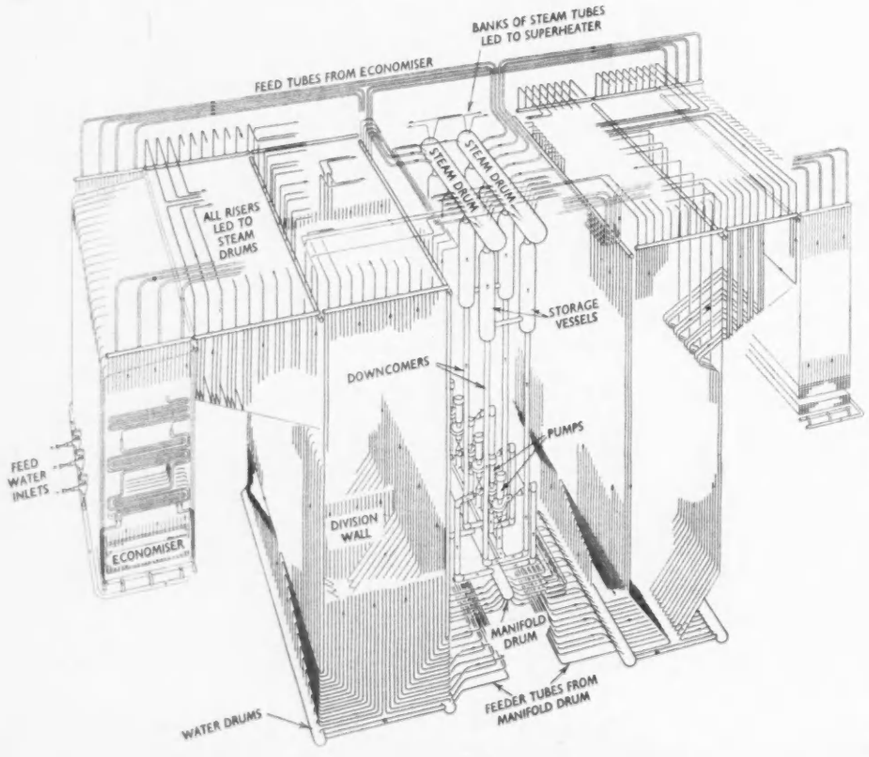


Fig. 1—Circulation diagram of 550MW reheat boiler for Thorpe Marsh

Operating Conditions of 550MW Boiler for Thorpe Marsh

Evaporation	3,750,000 lb per hour
Steam pressure	2400 lb per square inch
Steam temperature	1055 deg. Fah.
Reheat steam temperature	1055 deg. Fah.
Feed temperature	496 deg. Fah.
Guaranteed efficiency (based on the gross calorific value of the fuel)	90 per cent

As may be seen from the accompanying perspective diagram the boiler has two furnaces, each subdivided into two sections and fully cooled by water or steam tubes. One furnace controls the main steam temperature and the other the reheat steam temperature. Each furnace is 68ft wide by 28ft deep by 100ft high. Care has been taken to limit the height of main drum above ground; it is 148ft 6in above ground in the 550MW boiler, compared with about 135ft in a 200MW boiler.

Controlled and assisted circulation has been adopted for the boiler. By using pumps to augment the natural circulation, this system allows smaller bore tubes to be used for both risers and downcomers. The consequent reduction in wall thickness and temperature gradient offers gains in safety of operation and in capital cost.

The water supplied to each evaporating circuit is matched to the calculated heat absorption of each individual circuit by control nozzles. These nozzles improve circulating stability of the circuit and, consequently, wide fluctuations of heat absorption do not result in overheating of the tube metal on account of variable external fouling of the heating surface.

The circulating system is shown diagrammatically in Fig. 1. Although the boiler is divided into two separately cased twin furnace units, each sub-divided by a partition wall and provided with two steam release drums, the unit forms one single entity with both drums connected into the circulating system of the furnace so that the system operates as a unified and balanced unit with a single water level control. The water from each drum is extracted by equal downcomer legs to centrally positioned circulating pumps, in turn discharging to a common manifold. From this manifold multiple feeder tubes supply both furnaces whilst the risers forming the furnace walls discharge equally to both drums. The steam output from both furnaces is, therefore, equally distributed to both drums.

Feed water is also equally divided and ample cross-over pipes below the normal water level balance the water flow equally between the two drums. Equal steam withdrawal from both drums is ensured by taking half the steam to each of the primary superheater headers.

This simple unified system ensures that any one circulating pump will operate satisfactorily and feed both furnaces equally and simultaneously. With this arrangement, biased firing will not disturb the water levels or the steam pressure, a special advantage during steam raising periods.

Six circulating pumps will be installed, five of which will maintain the design circulation rate at maximum continuous rating. Indeed, it is anticipated that four pumps will be adequate for this purpose, whilst a corresponding number will be sufficient for lighter loads. These pumps are built integrally with the downcomer system and the design eliminates differential expansion and the consequent complication of piping. Fully automatic sequence control will be incorporated for starting the pumps in the event of failure.

The pumps themselves are vertical spindle,

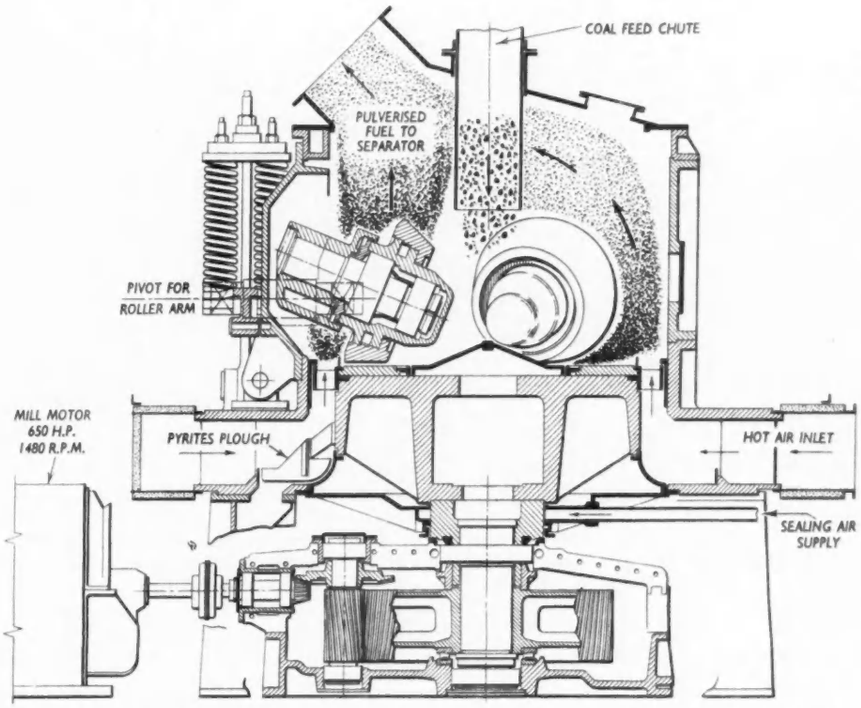
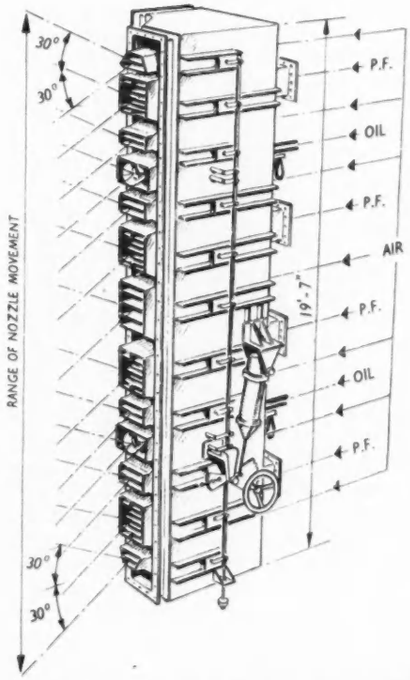


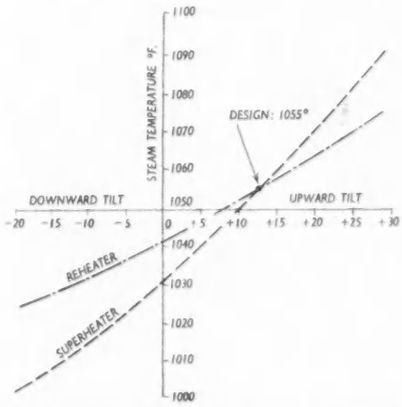
Fig. 2—" Lopulco " three-roller pressure mill, type 57 3.P ; table diameter 7ft 8in for Thorpe Marsh

single-stage, centrifugal machines, each driven by a squirrel-cage induction motor whose windings are immersed in the circulating water. The motor casing is built to withstand the full operating pressure of the system, whilst the windings are of a special design, capable of withstanding the pressure, whilst an external cooling system is mounted locally to ensure a satisfactory temperature level.

After separation in the drums the steam passes through turbo-separators and scrubbers to the superheater, whilst the water at saturation temperature passes around the drums before returning to the circulating pumps. This ensures that the whole of the drum interior surface is maintained at a uniform temperature, a very great advantage during a quick start.

In accordance with current practice the heating surfaces of the superheater have been arranged in such a way as to make the maximum effective use of inexpensive carbon- and low-alloy steels, thus reducing to a minimum the use of costly austenitic materials. The final stage of both the superheater and reheater is located away from the hottest zone at the top of the furnaces. In the highest gas temperature zone platen superheaters are used, consisting of a number of superheater tubes welded together to form a flat plate. The platens, spaced widely apart, are largely self-cleaning and are designed to operate for lengthy periods without " offload " cleaning, even when burning low-ash-fusion coals. An adequate system of cross-over tubes is incorporated in the superheater arrangement so that there is automatic compensation for any inequality of heat absorption. Radiant superheater surface is installed in the top of the furnace ; this arrangement permits the maximum economy of convection surface and improves the steam temperature control characteristic.





Figs. 3 and 4—(Left) Arrangement of tilting pulverised fuel burner. (Right) Estimated burner tilt/steam temperature characteristic at continuous maximum rating

With the advance in steam and reheat temperature the importance of close temperature control is paramount, not only for the sake of the turbine efficiency, but also to maintain safe operating limits for the metals of the boiler itself, the steam piping and turbine blades.

Spray type desuperheaters are installed for emergency use, but the primary steam temperature control is obtained by tilting burners on both the superheater and reheater furnaces. For this purpose a burner assembly is installed in the four corners of each subdivided furnace.

Each corner burner assembly consists (Fig. 3) of four coal nozzles and secondary air nozzles, arranged to discharge tangentially to an imaginary circle in the centre of the furnace to form a vortex. They are adjusted automatically in a vertical plane between an angle of +30 deg. and −30 deg. to the horizontal, so that the flame mass is projected into any desired position within the furnace between these limits. This design has the effect of varying the furnace exit temperature and consequently the superheat and the reheat temperatures. It is anticipated that constant temperature will be maintained within ±10 deg. Fah. over a range of 70 to 100 per cent of the maximum continuous rating. The effect of burner tilt is shown in Fig. 4.

Experience over several years has shown that this system of steam temperature control responds rapidly to any change in operating condition, and even with the large furnace, penetration of the jets to the centre of the furnace and the resultant turbulence of the gases, assures a high standard of combustion efficiency.

Each of the coal nozzles, progressively increased in size, is capable of handling about 6 tons of coal per hour with an associated air quantity of 60 tons per hour.

The pulverising mills, which have been specially developed for the large throughput required (total coal consumption 200 tons per hour), will be substantially larger than any other at present in commercial operation for coal burning. Eight " Lopulco " three-roller mills (Fig. 2) will be installed, each capable of handling over 50 tons of coal per hour, but six will normally be in operation, allowing two to act as standby for maintenance.

Each mill is capable of handling coal with a moisture content of up to 28 per cent, using hot air at 550 deg. Fah. for drying the fuel. The mill will have a centre feed enabling the outlets to be suitably positioned and thus provide a vertical straight-through feed to the mill itself without bends to restrict the flow of wet and sticky coal. Accordingly, the classifier (a double " whizzer " separator) has been positioned separately from the mill, but near to it. The oversize, hot, dry rejects from this classifier are redelivered to the centre main feed chute, mixing with the incoming wet fuel and thus assisting both in movement down the chute and drying within the mill itself. Pyrites and tramp iron is extracted from the mill in a similar manner to that used on standard " Lopulco " mills.

The fuel discharged from each mill is equally distributed to each half of the furnace and the output of each mill discharges to a single tier of burners, but the firing rate can be biased in favour of one or other of the furnaces if required.

Each mill is driven by a motor of 650 b.h.p., running at 1480 r.p.m. Lubrication of the gearbox is by pump, whilst the roller arm is lubricated by drip feed at a suitably controlled pressure to assure adequate, but not excessive, lubrication.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

OFF-PEAK ELECTRICITY

SIR,—Your leading article in your November 7 issue was opportune in that it coincided with the announcement of a new tariff under which electricity will be sold by the Central Electricity Generating Board to the Electricity Boards, and this tariff will, no doubt, in due course, be reflected in the Board's industrial maximum demand tariffs.

The increased demand charge and lower unit rate can be criticised on two counts.

First, it does not accurately reflect the cost of giving the supply ; this is bad economics in that consumption may be distorted in unexpected ways. As is shown by the published accounts, with the previous C.E.G.B. tariff, the annual revenue from the unit charge of 0·46d., with coal adjustment of 0·0006d. per penny change in the price of coal per ton, barely met the cost, including handling, of the fuel burnt ; the maximum demand charge of £6 per kilowatt provided all other expenses and the surplus. With the new tariff, therefore, having a lower unit rate of 0·41d. and a reduced coal increment, some of the fuel costs will have to be met from the demand charge.

Secondly, the new tariff, applied to industrial consumers, gives very little more incentive to increase load factor. The tariffs give the same overall price per unit at a load factor of just under 50 per cent. For those consumers whose electricity costs represent a substantial proportion of their operating costs, load factors normally lie between 40 and 80 per cent. At 40 per cent, the new tariff is about 3 per cent more expensive and, at 80 per cent, about 3 per cent cheaper. It would seem more realistic to fix the maximum demand charge at such a rate as to meet the fixed costs and to have two unit rates and coal increments to reflect the big difference in running costs between on and off-peak periods, thus giving a big incentive to off-peak loads when the most efficient base-load stations are running. An indication that the American power companies' approach is more realistic is that they frequently use the expression "dump power" for night supplies which can be provided cheaply and their higher system load factors are an indication that their attitude is having the right effect.

The article attributes to the Electricity Boards a lack of zeal in developing domestic off-peak loads, which does not seem justified, particularly as a comparison is made with the Electrical Development Association, which, of course, is financed entirely by the nationalised industry for the purpose of developing the use of electricity and publicising its potentialities. Again, the Electricity Boards are unable to provide storage heaters for domestic premises because of the purchase tax position. These heaters are exempt from purchase tax only on the understanding that their use is confined to industrial and commercial purposes ; they are expensive in first cost and would be uneconomically so if an *ad valorem* purchase tax were added.

HENRY CLAY

Westminster,
London, S.W.1,
November 12, 1958.

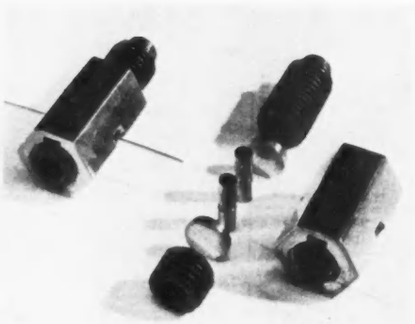
VIBRATING WIRE STRAIN GAUGES

SIR,—I have just read the article by Dr. Chapman describing the vibrating wire strain gauge now being used for long-term measurements on the new Mechanical Engineering Building at Imperial College. For the very similar tests commenced ten years ago on the new Government offices at Whitehall Gardens[1] a vibrating wire gauge was used that incorporated posts screwed into the steel to anchor the wire ; and the same practice, with variations in detail, has been followed in numerous other long-term tests since then. It is particularly interesting, therefore, that in the present gauge advantage has been taken of modern stud welding technique to revert to the original French practice of using welded studs.

Since, in explaining the decision to adopt welded studs rather than screwed posts in tapped holes, Dr. Chapman refers to the early Building Research Station gauge used at Whitehall Gardens, I should like to make a few further comments on the relative advantages and disadvantages of these alternatives. They are perhaps more evenly balanced than his article suggests.

(1) In terms of their rigidity there is, for instance, little to choose between them. The threads of both B.R.S. posts illustrated in my article[2] are prestressed in the process of assembly in such a way as to make the posts integral with the members into which they are screwed. Only as a result of faulty assembly could they change their setting as the structure was strained.

(2) Because the screwed-in posts provide closely reproducible anchorages for the wire, the effective gauge length is constant for a given spacing. Welded studs may give equally constant effective gauge lengths, but when the gauge for Whitehall Gardens was designed this was not proven and some doubt was felt about it. It would be interesting to have Dr. Chapman's experience in this respect.



Exploded view of gauge post, reproduced as Fig. 9 in R. J. Mainstone's : "Vibrating wire strain gauge for use in long-term tests on structures." *Engineering*, Vol. 176, pages 153-6 (July 31, 1953).

(3) The difficulty of drilling and tapping holes in the structure varies and does not, of course, necessarily preclude the fixing of the magnets independently of the cover. Independent fixing has been considered preferable in several more recent B.R.S. gauges and has been adopted without recourse to stud welding.

Assuming, on the one hand, that the gauge length is adequately defined with welded studs and, on the other, that screwed posts can be accommodated, it seems, therefore, that the choice between them must be made largely on the basis of expediency and cost in relation to the particular application in view. In the case of the tests at Whitehall Gardens, the drilling and tapping of the steelwork presented no difficulty because most of it was done by the steelwork contractors before the steel was delivered. The final assembly was completed well within the time available on the site. Stud welding would have been more costly and would have saved no time. At Imperial College the balance has been tipped in the other direction, chiefly by the time factor. But it would be interesting to know, as a guide for the future, how much the new gauge cost, how much of this cost was attributable to the stud welding equipment, and how many man-hours were worked on the two days during which the first forty-two gauges were assembled. It is not clear that this highly creditable performance is truly comparable with the low minimum assembly rate for one man of three or four gauges per day mentioned for other gauges.

The clamping of the wire in its anchorages is independent of the type of anchorage. The method of clamping adopted in the gauge used at Whitehall Gardens, in which the wire was held by tapered pins driven across its upper edge, did, indeed, result in a variable loss in tension on clamping according to the exact amount of the resultant deformations. But the variation of up to 0·5 ton per square inch was quite acceptable and would be for many other applications. The difficulty and costliness of manufacturing these posts to the close tolerances that had to be imposed were felt to be a much more serious drawback. Subsequent B.R.S. designs have adopted other methods of clamping to overcome this. The design which is illustrated here (Fig. 9, of my article) is perhaps functionally the ideal, not only in the ease with which the wire can be clamped at a desired tension, but also in the close definition of both the strained and the free vibrating lengths of the wire. It is made very largely of standard components, and even the reduced central diameter of the clamping pins is unnecessary if the right material is used. Clamping by means of bars, as in the Imperial College gauge, departs from the ideal in that the strained length of the wire (as distinct from

the length free to vibrate) is less accurately defined and may not be constant for all gauges under all conditions. Nevertheless, as several B.R.S. gauges incorporating clamping bars have shown, one of the attractions of the vibrating wire gauge is the extent to which such departures from the ideal can be made without noticeably reducing the accuracy of measurement.

I cannot close without congratulating Dr. Chapman on the care with which the new gauge has been detailed. I should also like to stress again the need to choose between alternative designs of gauge, and equally between alternative techniques of reading them, always in terms of the particular application for which they are intended and the resources available.

R. J. MAINSTONE

Building Research Station,
Garston, Watford, Herts,
November 3, 1958.

REFERENCES

[1] R. J. Mainstone, "Studies in Composite Construction, Part III : Tests on the New Government Offices, Whitehall Gardens." National Building Studies Research Paper No. 28 (in the press).
[2] R. J. Mainstone, "Vibrating Wire Strain Gauge for Use in Long-Term Tests on Structures," *Engineering*, Vol. 176, pages 153–6 (July 31, 1953).

Book Reviews

Functions of Real Variables, 407 pages ; **Functions of a Complex Variable,** 262 pages. By W. F. OSGOOD, Chelsea Publishing Company, 50, East Fordham Road, New York, 68, N.Y., U.S.A. Price 4.95 dollars.

OSGOOD's two treatises on the theory of functions were originally published in 1936. They have now been re-issued in a single volume by the Chelsea Publishing Company, and a useful index has been appended to each work.

We gather from the introduction that the book on the real variable is designed for students who have completed a course in advanced calculus. The precise implications of this statement are not always clear for while several quite difficult concepts are treated as familiar, much more elementary topics are discussed at inordinate length. The order in which various ideas are introduced is also, at times, puzzling. Thus, Chapter I deals with elementary theorems on infinite series, but in Chapter II the author goes back to the foundations of analysis and discusses the construction of the number system. Chapter III is mainly devoted to properties of continuous functions, and Chapter IV to Taylor's theorem and theorems on implicit functions. There follows, in Chapter V, an admirably lucid account of uniform convergence. Then, after an excursus into trigonometric functions and further discussion of the theory of infinite series, the author turns to repeated integrals, integrals with parameters, Fourier series, and Fourier integrals. A special chapter is reserved for the gamma function, and the book concludes with a chapter on existence theorems in the theory of differential equations.

There are some surprising omissions. Thus superior and inferior limits are not introduced at all, and the second mean value theorem of the integral calculus is absent. Repeated integrals are used extensively but multiple integrals, though mentioned, are never defined. This is unfortunate, especially as Green's theorem forms part of the discussion ; here the author relies on results from his *Advanced Calculus*. There are many other perplexing touches. For example, the term "linearly independent" on page 223 is not defined ; the proof of the theorem on mixed partial derivatives (page 269) is based on the integral calculus ; and the theorem on page 301 seems incomprehensible.

The volume on the functions of a complex variable follows a less devious route and has a much clearer aim. Yet here, too, there are many infelicities. The account begins with the discussion of complex numbers as ordered pairs of real numbers ; but before this is completed, the reader's attention is distracted by a premature interpretation of complex numbers as vectors. Chapter III is devoted to an introductory treatment of conformal mapping ; surprisingly, the bilinear transformation only appears towards the end. The crucial chapters are V, VI and VII ; these deal with Cauchy's integral theorem and integral formulæ, Taylor and Laurent expansions, the maximum modulus principle (but not Schwarz's lemma), the residue theorem, and analytic continuation. It is inevitable that these chapters should have a slightly old-fashioned flavour : modern accounts naturally rely to a much greater extent on topological ideas. However, this change of emphasis is of little moment for a reader who is mainly interested in the theory of functions as a tool. Osgood's proof of Cauchy's theorem is based on Green's theorem, and more than fifty pages separate it from the residue theorem. Moreover, the reader receives little idea of the power and usefulness of the residue theorem. The last two chapters deal with harmonic functions and with conformal mapping of simply-connected regions ; the final climax is the proof of Picard's theorem and of the Riemann mapping theorem.

However, our reservations must not be allowed to obscure the merits of the work. Osgood's two books contain a great wealth of material, all of it interesting and most of it carefully presented and fairly easy to follow. There are numerous and very helpful exercises ; and the price for a book of over 650 pages is surely moderate.

Applied Mathematics for Engineers and Scientists. By C. G. LAMBE, B.A., Ph.D. English Universities Press, Ltd., 102, Newgate Street, London, E.C.1. Price 42s.

THE difficulty of assigning a clear and unique meaning to the term "engineer" has exercised many minds, and a similar difficulty is arising over other such appellations. In some fields, for example, "scientists" of various brands have become difficult to distinguish from those of their colleagues who name themselves engineers. In fact, the distinction between a particular engineer and a particular physicist in, say, the telecommunications or nuclear industries, may be much smaller than the distinction between the man who builds dams and the man who designs turbines ; yet these men are called, alike, engineers.

The book under review, bearing the title it does, is thus addressed to a large and rather amorphous aggregation of individuals. While one would agree that mathematics is perhaps the only tongue in which all these individuals possess (or should possess) some fluency, one wonders whether a text of a little over 500 pages on applied mathematics can carry such a comprehensive title ; especially when the not excessively special interests of many scientists and engineers must fail to be considered at all. Statistics, to name but one example, is becoming increasingly important to technical people, but the application of this branch of mathematics finds no mention in the present work. This implies no adverse criticism of the treatment actually given. As the author explains in his preface, he has been guided by syllabuses for London B.Sc. examinations, and for the purposes he states in his preface the text appears to be adequate. He deals with the statics and dynamics of rigid and elastic bodies, and with fluid mechanics. He does not cling to the well-trodden paths, introducing servo-mechanisms, for instance, in a chapter on the oscillation of particles. More modestly titled, the work would be quite acceptable, but named so ambitiously, and clothed in a discordantly coloured jacket, the book tends, before being opened, to induce a lifting of eyebrows and a lowering of eyelids. The contents deserve better, for though the text is marred by some printing errors, it should be helpful to a number of students. There are more than a thousand worked exercises.

Nuclear Power Year Book, 1958–59. Edited by WILLIAM DAVIDSON, M.Sc. (Eng), D.I.C. Rowse Muir Publications, Ltd., 3, Percy Street, London, W.1. Price £2 12s.

THE second edition of the *Nuclear Power Year Book* is in substantially the same form as the first, and this in itself is evidence that the original design was a good one. As in last year's issue, the book is divided into eight sections. The review articles that make up the first section of the present edition are all new, and the remaining sections have been revised and expanded. Section 2, which provides information on international and national authorities throughout the world, has particularly benefited from this revision, while the continued vigour of British endeavour is brought out by the size and content of the last four sections of the book. These comprise a buyers' guide, "who's who," list of company addresses, and a list of trade names. The two remaining sections are devoted to isotopes and technical matters. The tables of isotopes have been rewritten and now deal with nearly 1400 nuclides. Data on aluminium, beryllium, magnesium, niobium, sodium and sodium-potassium alloys, steels, vanadium and zirconium have been added, as well as tables and curves giving the viscosity, specific heat, thermal conductivity and density of ordinary water and some data on heavy water.

While we would agree with Sir Christopher Hinton when he writes in his foreword that this year book will help in the wise deployment of effort, we also look forward to the day when the final sections of this volume can be expanded to include at least some of the people and products of other countries : for not only would the usefulness of these sections then be much enhanced, but the forward position of British enterprise in nuclear engineering would be so much the better demonstrated.

Books Received

The Multiform Manual. By T. Hanson. Wickman, Ltd., Post Office Box No. 44, Banner Lane, Tile Hill, Coventry. Price 75s.

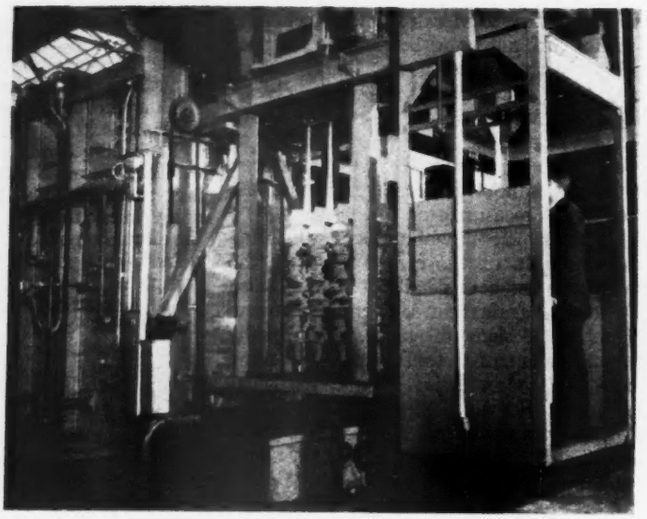
Engineering Thermodynamics. By D. B. Spalding and E. H. Cole. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1. Price 28s.

Electricity Undertakings of the World : The Red Book, 1958/59. Benn Brothers, Ltd., Bouverie House, 154, Fleet Street, London, E.C.4. Price 30s.

Physical Basis for Electrical Engineering. By Thomas L. Martin, Jnr. Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2. Price 30s.

B.B.C. Television—A British Engineering Achievement. B.B.C. Publications, British Engineering, 35, Marylebone High Street, London, W.1. Price 2s. 6d.

Heat Treatment Plant for Crankshafts

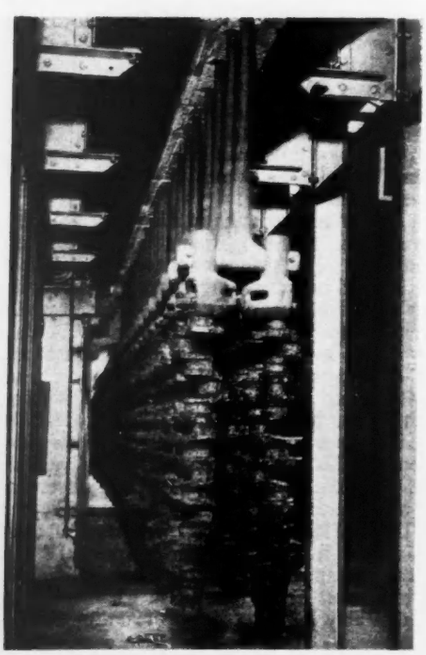


A continuous heat-treatment installation which has been put into operation in the crankshaft processing department of the Scottish Stamping and Engineering Company, Ltd., at Ayr, is designed for a throughput of 750 crankshafts a day. In this installation the crankshafts, slung from overhead brackets, are carried through a hardening furnace to the quenching bath station, shown on the right, where they are traversed across to a tempering furnace line.

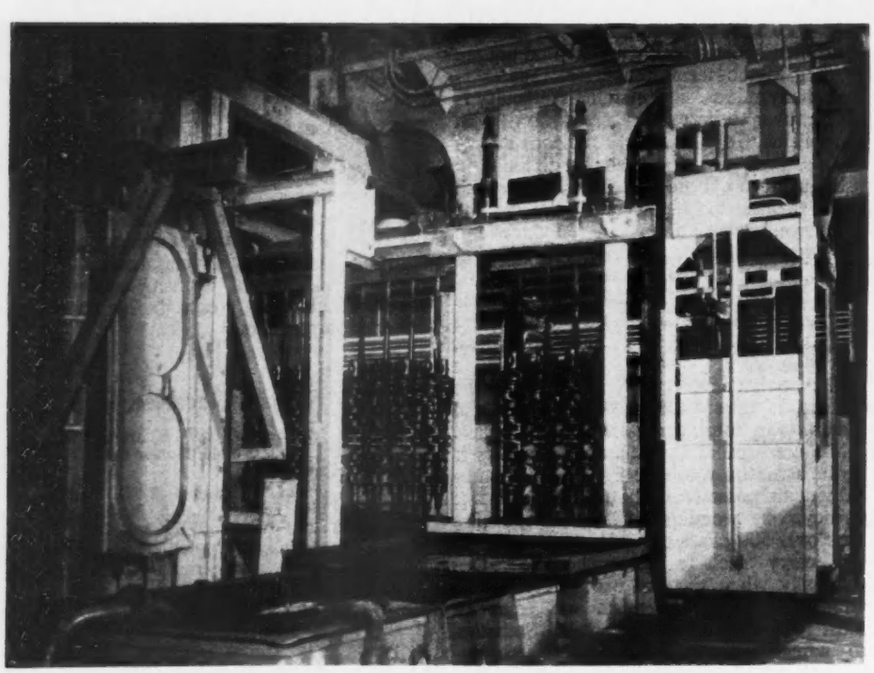
THE capacity of the heat-treatment department at the Ayr works of the Scottish Stamping and Engineering Company, Ltd., has been increased, and the section integrated with a new crankshaft processing department, by the introduction of a continuous hardening and tempering furnace installation. This town-gas-fired furnace installation has been designed and built by the Incandescent Heat Company, Ltd., of Smethwick, to accommodate a wide range of crankshaft sizes: it has a throughput of up to 750 crankshafts a day. The hardening and the tempering furnaces are arranged side by side, with the quench at one end of the installation.

The inside dimensions of the hardening furnace are 43ft long by 2ft 6in wide by 6ft high; it is fired by a low-pressure, multiple-burner system, giving direct under and over firing and longitudinal three-zone control. The heating gases are projected from the burner openings into the furnace chamber for circulation around the load, giving even distribution and heating by direct firing and radiation. The 57ft long tempering furnace is divided into four zones; the first two zones are indirectly fired with a multiple-burner system, the second and third zones being fired by separate gas recirculating heater units with a single burner and high-velocity recirculating fans. For the tempering treatment, when radiation effects are negligible, the burner system provides turbulent convection currents, evenly distributed for precision treatment and accuracy of control. Each zone in the two furnaces constitutes a separate firing system for the appropriate length, with independent gas supply, gas governor, back-pressure valve, and combustion air blowing fan with automatic temperature control. Waste gas extraction is by auxiliary and main exhaust outlets, positioned and graduated in conjunction with the chimney flue control dampers to equalise furnace pressure conditions.

As can be seen from the accompanying illustrations, the furnace installation is somewhat unconventional in that the crankshafts are slung from an overhead equipment and carried through the zones in a vertical position, as distinct from the more usual method of being carried on a moving hearth. It is claimed that this method of vertical suspension provides excellent conditions for heating and soaking, entirely eliminating "hearth" effect which can be experienced in static and horizontal conveyor furnaces. Maximum efficiency is obtained in quenching as the shafts in the tank hang freely, completely separate from each other, and by this method of vertical heating and quenching heat-treatment distortion is stated to be greatly reduced. Temperature variation in the independently controlled firing zones gives an accuracy of plus or minus 5 deg. Cent. in the hardening furnace heating and soaking zones and heating zone of the tempering furnace, the final soaking zones with recirculating atmosphere giving a working accuracy of plus or minus 2 deg. Cent.



Hanger assemblies loaded with crankshafts ready for pushing into the hardening furnace



Hardened and quenched shafts being loaded into the tempering furnace

The crankshaft forgings are suspended from heat-resisting alloy adaptor support brackets attached through tee-bars to overhead bogie carriages, which run on rails above the furnaces. The brackets are designed to take a range of varying diameter crankshaft end flanges and the support bars pass through a continuous slot in the roofs of the furnaces. This slot is sealed by sand seals, scraper plates being fitted to the sides of the bogies. Each bogie has four hanger bars for the carriage of eight crankshafts which constitute

a unit load for the heat-treatment cycle and quench.

A traversing manipulator is situated at each end of the furnace line, and at the outgoing end of the hardening furnace facilities are provided for quenching in either oil or water. In addition to the normal circulating pumps for cooling, each tank contains a series of high-pressure jets through which the quenching medium, straight from the coolers, is directed immediately on to individual forgings, thereby obtaining efficient agitation around the load of immersed crankshafts. An automatic quench timer is set for the forgings to be raised from the quench with a given degree of residual heat to allow for partial stress relief prior to tempering.

The normal sequence of operations with this installation starts with a bogie load of crankshafts being extracted by the manipulator from the discharge end of the hardening furnace, as shown in one of the accompanying illustrations. This load is lowered rapidly into the appropriate quench tank for the preset time. During this operation a load of forgings is charged into the other end of the hardening furnace. The charging manipulator is then traversed across to the discharge end of the tempering furnace and extracts the leading bogie load of shafts. This bogie is traversed across to an overhead turntable, where the heat-treated shafts are unloaded and a fresh group slung on the brackets. The manipulator is then used to reposition the reloaded bogie at the starting line leading to the hardening furnace. During the bogie unloading and reloading period the quenching operation at the opposite end of the furnaces is completed. The load of quenched shafts is traversed by the manipulator to the entrance line to the tempering furnace, where it remains for a draining period covering two operating cycles to prevent carry over of excess quenching media into the charging end of the tempering furnace. As the bogie enters this draining section a previously quenched load is fed into the preheating zone of the tempering furnace.

When the crankshafts leave the heat-treatment section they are taken by a monorail conveyor to a hot straightening bay. After any necessary straightening the shafts pass on to a travelling monorail cooling bank, the speed of which can be adjusted to suit the rate of cooling. At the end of this bank the cold crankshafts pass through a hardness inspection bay and on to a shot blasting section. They then pass through a surface inspection section, where any shafts showing surface defects or flaws are sidetracked through a fettling operation and subsequently back through surface inspection. Once cleared on surface inspection the crankshafts are carried again by monorail to a final bay, which contains fixtures for dimensional checking and machines for centring and facing ends if required. We are informed that the crankshafts heat-treated in this new plant have better physical properties, more uniform hardness values and better machining characteristics than those hitherto treated by batch methods in the factory.

Motor Cycle Engineering

The thirty-second International Cycle and Motor Cycle Show at Earls Court was opened last Saturday by the Minister of Transport and Civil Aviation: it continues until to-morrow. Exhibitors are less severely restricted than at the Motor Show, and some of the most interesting exhibits are machines that are not offered for sale.

THE exhibition of the British Cycle and Motor Cycle Industries Association, Ltd., a biennial event, does not on this occasion bring any new classes of product within reach of the customer. The exceptions to this are British-made motor cycles with weather protection for the rider, as exemplified by the Ariel "Leader" (see page 144, July 25, 1958) and a pedal cycle with mudwings, handlebar screen, and splash guards of "Fibreglass," known as a "Scoo-Ped." As at the 1956 show, the only all-enclosed motor cycle is the "Maicomobil," a 197 c.c. two-stroke. It may be hypothesised that the reason why cowlings to give low drag as well as weather protection for the rider are not available from the native manufacturers—although the Avon "Streamliner" body for addition to many of the higher performance models is shown by Mitchenall Brothers, Ltd., of Durrington—is because the F.I.M. regulations for racing virtually demand the "dolphin" fairing, and all development and experiment have been concentrated on this class. As was announced some time ago, both Velocette and Royal Enfield models with such equipment are available.

A development which, since several examples have appeared, should be recorded, is the use of very large rear mudguards fitted outside rather than inside the supporting structure, and thus rendering it far easier to clean the outside of the machine: such a provision is to be seen on the new 250 c.c. Norton parallel twin. However, these tails are kept quite narrow and do not add to the carrying capacity of the machine, presumably to prevent the machine looking tail heavy. On the "LE" Velocette and the Ariel "Leader" side panniers are fitted, and on the "Maicomobil" there is both enclosed space and a spare wheel stowage on the tail, showing that the installation of protective panelling can have substantial secondary advantages.

An unexpected and interesting exhibit is a pioneer effort by a British manufacturer in this direction, a Vincent "Black Knight" such as was shown in 1954 and, in common with all other Vincent motor cycles, has now been discontinued. This example is exhibited by the Vincent H.R.D. Owners' Club, and is illustrated here: the distinctive feature of the machine is that headlight and windscreen turn with the handlebars.

Another exhibit of great technical interest is the 500 c.c. racing Guzzi. This machine is distinguished by a liquid-cooled V-8 engine, which rotates in the fore-and-aft plane in the normal way. Our illustration shows the rear bank of cylinders, with the spark plugs in between the two camshaft housings, and beyond them the eight carburetter chokes interlacing at right angles. Engine and gearbox are built as one unit and hung beneath the backbone frame. The radiator is low down in front of it, and cooling air enters the streamline shell through forward-facing apertures.

As at the last show, the machine that triumphed in the year's Moto-Cross championship is exhibited, and again it is a 500 c.c. overhead camshaft single. This year, however, it is a F.N. on the stand of Fabrique Nationale d'Armes de Guerre S.A., and is surrounded by 49 c.c. mopeds. It serves as a reminder that for at least three decades it has been realised that the ultimate

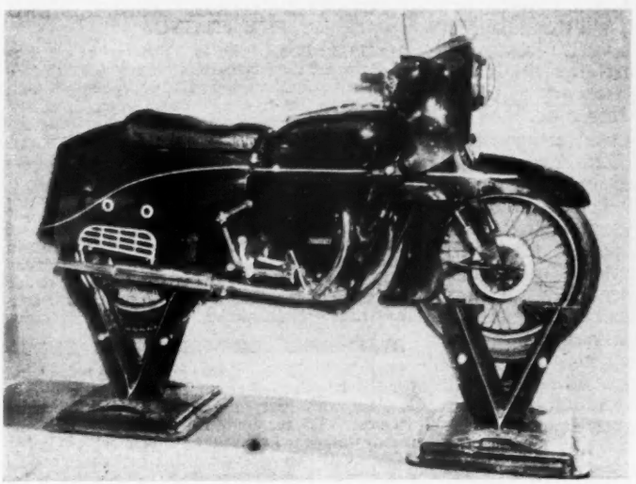


Fig. 1—A "Black Prince," one of the enclosed models in the Vincent "D" series. The grid and fenders to carry panniers were not standard fittings

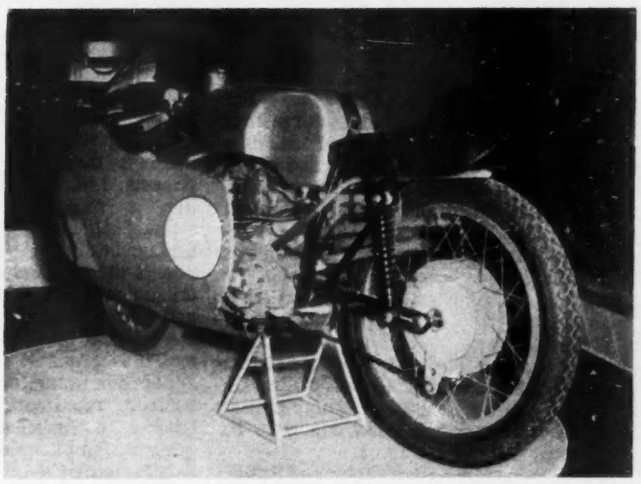


Fig. 2—The 500 c.c. racing machine in its most ambitious form: the Guzzi with a water-cooled V-8 engine. Notice the generous crankcase vent pipe, so characteristic of Italian practice

performance can only be wrung from a poppet-valve engine by overhead camshaft valve gear, and draws attention to the anomaly that German and Italian factories are exhibiting fully equipped motor cycles with such engines, while in this country they are shown only on racing machines.

Another obtrusive difference between Continental practice and that of Great Britain is, of course, in the status of the moped. In this country the motor-assisted pedal cycle is rendered highly unattractive by legislation, and so such machines are not to be seen on the stands of the motor cycle manufacturers. Because of the unfavourable legal status of such machines, the British examples would be expected to be of the least ambitious description, and such a trend is exemplified by the recently introduced Raleigh moped, which is as nearly as could well be a bicycle with an engine added : in fact, by withdrawing a pin

Fig. 3—The " Sunbeam " scooter has little in common with Sunbeam motor cycles : notice the assymmetry of the front suspension. Under the flaring front mudguard is stowed the tyre pump

on the high speed gear of the countershaft assembly the engine can be completely disconnected and the machine treated as a pedal cycle. This provision is necessary because there is no clutch, stopping and starting being achieved with the decompressor ; this construction virtually rules out the use of the machine as a motor cycle trainer. Many components, such as brakes, are common to Raleigh pedal cycles. The engine is unusual in having a deflector piston: it consists of a flat-topped piston with two recesses cut in the very deep top land opposite the two transfer ports. Our impression of a single demonstration vehicle was that the low-speed pulling expected of a two-stroke and mandatory in this application was not realised. A rather unusual feature of the machine is that rich mixture for initial starting is obtained by filling a capacity well, thus eliminating the need for any adjustment after the machine has been started. Mixture strength at starting is clearly less critical on an engine that can be motored more or less indefinitely than on one that can only be kicked over with a large effort.

Another virtually unique feature of British motor cycle practice is the use of the parallel twin configuration on a four-stroke engine, and since this layout offers the nearest approach to a single-cylinder two-stroke, it is not surprising that it has now spread into the scooter specifications. It should be made clear, however, that the most conspicuous feature of the B.S.A. " Sunbeam " and Triumph " Tigress " scooters, in both of which four-stroke 250 c.c. twin or two-stroke 175 c.c. single engines are alternatives, is that they reject absolutely motor cycle engineering practice, despite the fact that their sponsors are generally regarded as established motor cycle manufacturers (although at the previous show B.S.A. attracted a certain amount of attention with a scooter called the " Beeza," which did employ motor cycle techniques). This divergence is obvious in the most basic features of the design, which does not use hemispherical combustion chambers (one detail in common with the previous overhead camshaft Sunbeam), has an engine speed clutch, and loads the sliding members of the telescopic front suspension in bending under all conditions. Distinctly unusual is the method of attaching the cowlings : the edges are turned outward to form a flange, and two flanges joined by bolts and (not captive) nuts. The most consistent departure from preceding models is in the rider's controls : the kick starter works in the opposite direction (clockwise, viewed from starboard), and the gear shift works backwards and forwards, instead of up and down, calling for movement of the whole foot instead of just the toe. The " neutral " finder moves the selector upwards out of whatever gear is engaged, so that it finds neutral perfectly from first only and not at all from fourth gear. There is a curious cover over the handlebars which, as our illustration shows, does not protect the hands, but does obscure the speedometer.

These scooters are, we believe, unique in that they employ a separate starter and generator. The additional weight and maintenance load is presumably dictated by the characteristics of the twin-cylinder engine, which has a higher piston ring drag and the large energy consumption of valves with return springs. The starter drives through a manually engaged gear train with a large reduction ratio. No starter is available on the two-stroke engine, probably to avoid burdening the service organisation with the products of another source of electrical equipment. (Self-starter models have 12V Lucas generators, others 6V alternators, Wico-Pacy on the single and Lucas on the twin.)

These vehicles also have unusual starting techniques. Zenith carburetters are used, and are reached by lifting the saddle. Rich mixture is selected by pushing down a plunger on top of the carburetter, and the slide lifts again as the throttle is opened : assuming that the engine is not lost after the initial start, it is therefore not necessary to touch the mixture control more than once.

Among the accessories and components, there is displayed by G.B. Cycle Components, Ltd., a hydraulic braking system : this is straightforward in construction, although, interestingly enough, it uses nylon tubing, and the most important feature to note is the excellent example it sets in maintaining complete independence between front and rear hydraulic systems. This system is applicable to other controls, such as throttles, and it is probable that its most important application on motor cycles will be to clutch controls, the frequent operation of which renders low mechanical efficiency in the transmission onerous.

An unusual and particularly interesting exhibit on the stand of Phillips Cycles, Ltd., is a machine to carry out the truing of wheels, an operation which hitherto has demanded more labour than any other in the assembly of a bicycle. The wheel is built up by hand to the stage of starting all the nipples on the spokes, and is then located on the machine. Up to forty motor-driven spanners then rise up and move out to engage the square inner ends of the nipples, while an electromagnetic pick-up comes down to nearly rim height and rotates around the rim. The spanners are then driven in the " tighten " direction, but under the command of an electronic control system individual motors are cut out so as to minimise errors of truth in the wheel. In the drive to each spanner there is a torquemeter, and movement continues until the

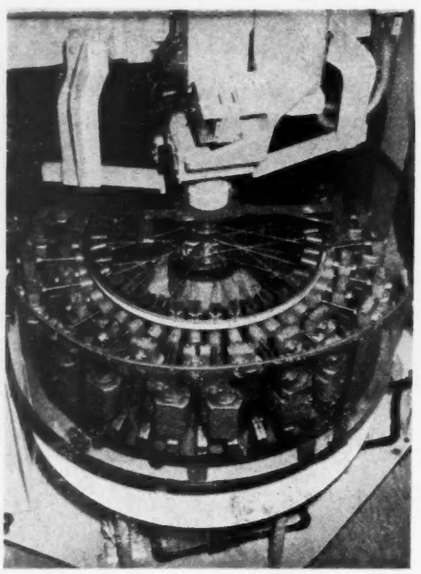


Fig. 4—Cycle wheels with up to forty spokes can be trued within one minute on this machine. The rotating scanner detects run-out and stops the appropriate spanners to minimise errors

total of all torques reaches a desired value. The spanners then move inwards, rotate until an axial slot in the socket is uppermost, and drop clear of the spokes. The truing time is about one minute, and the truth is, we are advised, within 0·001in. The plant was developed in conjunction with Tube Investments Technological Centre.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

ACID-RESISTING SILICON IRON PIPES AND PIPE FITTINGS

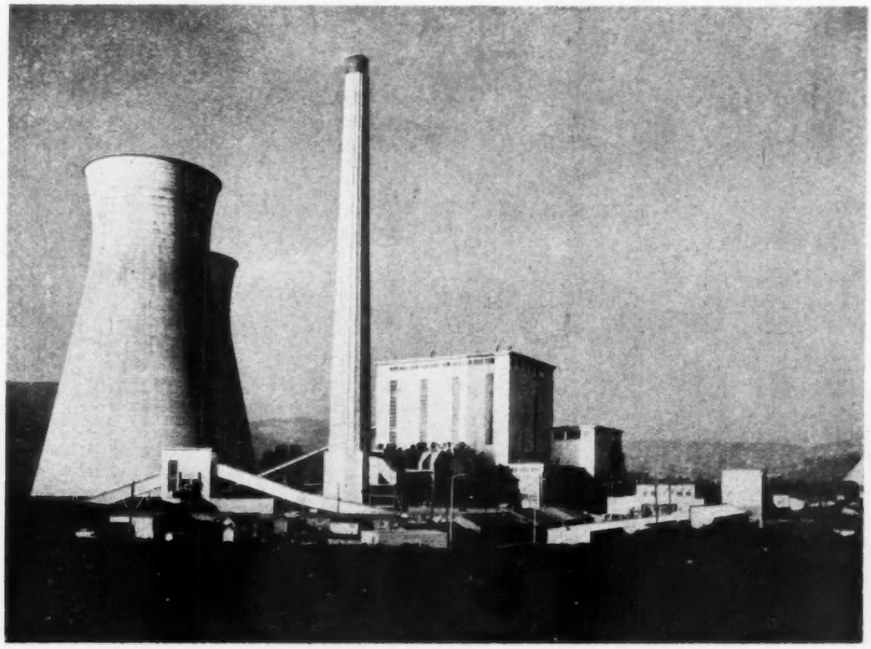
No. 1333 : 1958. Price 6s. This revised publication deals with three types of pipes and pipe fittings—cone ended, spigot and socket, and plain ended—in a size range of 1in to 12in nominal bore. The new edition includes requirements for loose coupling flanges and requirements for the 2½in (64mm) and 5in (127mm) sizes given in the first edition have been omitted

The specification contains clauses on material, workmanship, finish, testing and marking and (for the flanges) drilling and bolts and nuts. Each of eight tables of standard dimensions is presented in association with a " keyed " diagram. An appendix lists the information which a purchaser should provide when submitting an inquiry or order ; another contains a recommended method for coupling plain pipes.

DIMENSIONS FOR WORM GEAR UNITS

No. 3027 : 1958. Price 3s. This publication specifies the principal external and mounting dimensions for worm gear units of 4in, 6in and 8in centre distances. Its requirements are similar to those already worked to by the gear manufacturing industry.

One of its two appendices lists preferred nominal gear ratios ; and the second draws attention to the information which should be included in an order. An information plate on each unit is required to bear the " B.S. number " in association with the size designation shown in the standard, and particulars of the gear ratios.



Rogerstone Power Station

Increasing industrial load in South Wales indicated that additional generating plant was required at the eastern end of the 66kV network. A 92-acre site at Rogerstone was acquired on which a 120MW station has been built for the South Wales Division of the Central Electricity Generating Board and was officially opened on October 30. The station is equipped with two 60MW turbo-alternator sets supplied with steam at 900 lb per square inch and 900 deg. Fah. from two boilers each having a steaming capacity of 550,000 lb per hour.

DURING the war additional generating plant was installed in South Wales to meet increased demands for power, demands which have continued to increase since the war due to expanding industries. To meet power requirements No. 3 and No. 4 machines were installed at Llynfi and new stations were built at Uskmouth and Carmarthen Bay. However, the industrial loading indicated that additional plant was necessary at the eastern end of the 66kV network and a site at Rogerstone near Newport was selected and Ministerial consent obtained for the construction of a new 120MW station. The 92-acre site was originally low lying mixed farming land in the valley of the River Ebbw and along its east bank. Our first illustration gives a general view of the station which was opened by Sir Christopher Hinton on October 30.

Close to the site is the main railway line, so that coal supplies offered no difficulty, and nearby is the Newport–Risca road from which it was necessary to cut a new access road. Waste tipped from the existing rail track formed embankments which now carry the storage and tippler sidings while spoil from the roadway cutting was used to raise the level of the site by 4·5ft to a height of 3·5ft above the flood level of the river. Examination of the ground indicated that it consisted of 20ft in depth of alluvial deposits with boulders and cobbles above rock marl; thus since conventional piling would have been difficult, piles cast *in situ*, were sunk using Benoto machines. Each of the 149 piles is of 1m diameter and of 65ft average length and capable of sustaining a load of 300 tons. The main buildings are 226ft long by 360ft from the outer turbine house wall to the chimney and 140ft high and are steel framed and clad with brick to a height of 36ft. Above this the cladding consists of fluted aluminium sheeting on the outside and galvanised sheet steel on the inside with an insulated filling. Reinforced concrete cast *in situ* was used for the boiler house roof and pressed steel sheets coated with bitumen for the turbine house roof. Except for the basements of the circulating water pump house, the tippler, and coal crusher, very little excavation was required. Five reinforced Benoto piles were cast in the foundations of the wall between the pump house and the turbine house and sixteen piles carry the 350ft high reinforced concrete chimney which has a base diameter of 20ft and an exit diameter of 14ft 2in.

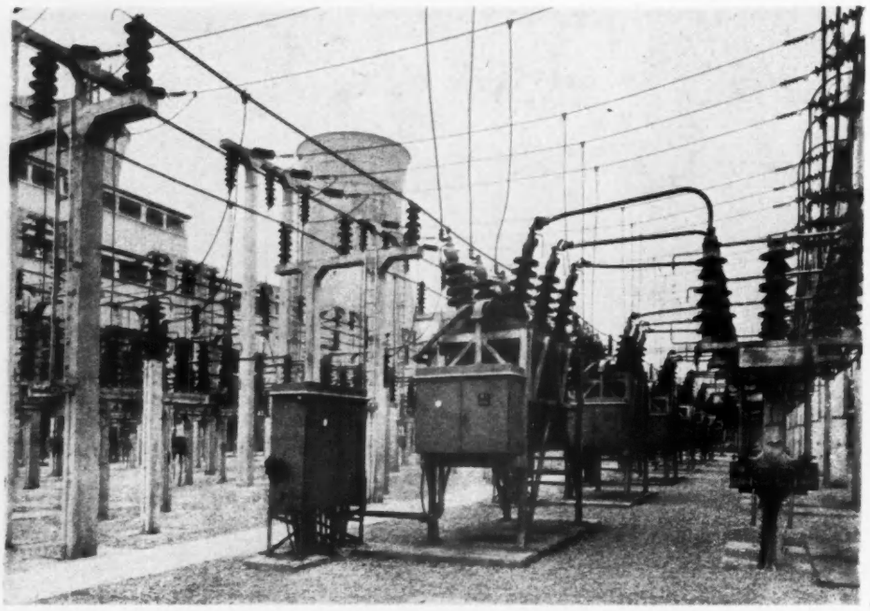
There is storage for 240 wagons in the sidings and coal, which is delivered by rail, is required at a rate of 1100 tons per day. Two side tipplers which are completely dustproof (the dust being trapped and returned to the tippler hopper) are mounted in a single house and each can handle twelve 24½ tons capacity wagons per hour. The coal handling system has a capacity of 250 tons per hour and the coal is carried by single 30in conveyors to the screening and crushing plant where it is reduced to the size of a 1in cube. A radial conveyor stocks out the coal which is reclaimed by being bulldozed into underground hoppers and is then carried by conveyor belt to the bunkers.

Firing aisle in boiler house

Turbine room with two 60MW turbo-alternators

Steam is raised at 950 lb per square inch and 925 deg. Fah by two single drum radiant furnace boilers each having a capacity of 550,000 lb per hour and operating under forced and induced draught. The firing aisle is illustrated on page 811. The forced draught fans, of which there are two per boiler, are rated at 83,000 cubic feet per minute, the corresponding rating of each of the two induced draught fans being 119,000 cubic feet per minute. The furnace volume is 62,000 cubic feet and its radiant heating surface amounts to 10,060 square feet and the primary superheater having, one horizontal and one pendant section, has 19,570 square feet of surface while the pendant multi-loop secondary superheater has a surface of 7850 square feet. Interposed between the superheaters is a spray pattern attemperator which automatically maintains the final steam temperature at 925 deg. Fah. The multi-loop pattern economiser has a heating surface of 26,000 square feet and each boiler has two Ljungstrom vertical spindle, rotary air heaters each of 74,500 square feet heating surface. Coal for the boilers is held in four bunkers, two per boiler, each of 300 tons capacity and supplied from the 70,000 tons capacity coal store. Associated with each boiler are four vertical pressurised ball mills and four primary air fans, each rated at 17,500 cubic feet per minute. Any three of the mills and associated fans will maintain full load. The pulverised fuel is fed to sixteen downdraught burners located in sets of eight at the top of the burner arches on either side of the boiler, and initial firing is by eight, electrically ignited, automatic oil burners located four per side in the side walls below the pulverised fuel burners. Coal is received from several sources, the ash content being as high as 30 per cent with the average at about 25 per cent, and the average calorific value being 11,000 B.Th.U. On acceptance tests the boiler efficiency was returned at 91 per cent, and after nine months without cleaning the efficiency was about 89 per cent.

Before entering the chimney the waste gases pass through electrostatic precipitators, two per boiler, and these have proved 99·5 per cent efficient when coal having an ash content of 20 per cent was being burnt. Dust from the precipitators falls into a buffer tank, to which dust from the chimney and economiser hoppers is blown through pipes. A Fuller Kenyon dust pump with an associated buffer tank and compressed air plant is installed for each boiler. Boiler ash is removed by high pressure water jet, and the ash reclaimed from settling chambers. Both ash and dust are transported to the disposal area by dumpers and it is of interest to note that grass has been grown on an experimental area sprayed with nitrate of chalk so that the dump area can be eventually turned into a cultivated area.



66kV outdoor switching station, showing busbars and isolators, circuit breakers and line isolators

Make-up feed water is obtained by treating town's water in a demineralisation plant which is arranged with units in parallel and has a capacity of 5000 gallons per hour. The raw water is treated in a hydrogen exchange unit, where the dissolved salts are converted into acids and then passed through a degasser tower where carbon dioxide is removed with air. Treatment in a mixed bed demineralisation plant follows and the dissolved acids and any silica in the water are removed to provide water having dissolved solids not exceeding 0·5 p.p.m. Each unit will treat 64,000 gallons of water between regenerations. The feed heating and condensing system, which raises the feed water to 385 deg. Fah., consists of two shell, three pass condensers, two h.p., two l.p. and one l.p. deaerator, and two horizontal, two-stage, electrically-driven extraction pumps having a normal duty discharge head of 175ft. Three 650,000 lb per hour motor-driven feed water pumps are installed and can deliver against a pressure of 1150 lb per square inch.

Steam is delivered through 0·5 per cent chrome-molybdenum steel piping at 900 lb per square inch and 900 deg. Fah. to the two 60MW, 3000 r.p.m., turbo-alternators of three cylinder tandem compound multi-stage reaction design, illustrated on page 811. The h.p. cylinder has nineteen stages, the i.p. cylinder nineteen, and the l.p. cylinder six stages, and the steam is exhausted from the double flow l.p. turbine into twin three-pass condensers which maintain 28·7in of vacuum. An initial vacuum of 20in is raised in the condensers in five minutes by means of a single-stage air ejector using steam at 400 lb per square inch, while the operating vacuum is maintained by either of two three-stage air ejectors using steam at full pressure.

The alternator is totally enclosed and directly cooled with hydrogen at a pressure of 15 lb per square inch gauge and circulated by shaft fans. The alternator exciter is driven at 1000 r.p.m. through gearing from the main shaft and the terminal voltage is 11·8kV, the full load current being 3670A at 0·8 power factor. Copper busbars, in an aluminium duct pressurised with warm air, link the alternator terminals to the 75,000kVA generator transformer which steps up the output voltage to 66kV.

The design full load heat consumption is 9211·4 B.Th.U.s per kilowatt-hour and the steam consumption 8·435 lb per kilowatt-hour.

The hydrogen cooling the alternator is in turn cooled by distilled water in four coolers situated in the stator casing and the distilled water is cooled in external coolers using circulating water.

To condense the exhaust steam from the turbines requires about 4,000,000 gallons of cooling water and to fulfil this requirement, since the minimum flow of the River Ebbw is insufficient, two 2,250,000 gallons per hour cooling towers have been built. These have a height of 286ft above sill level, where

Power station sound-proofed and air conditioned control room

the diameter is 192ft, a throat diameter of 100ft and a diameter at the top of 116ft. The depth of the pond below sill level is 6ft and two 20,000 gallons-per-minute pumps, per machine, having a normal capacity head of 65ft, draw water from the ponds through 54in diameter pipes and discharge into the condenser inlet main through hydraulically-operated non-return valves. Water is tapped off to supply the oil coolers, distilled water coolers and seal oil cooler on each machine. Make-up cooling water is drawn from the River Ebbw by three 1240 gallons per minute pumps, one of which is a stand-by, installed in a house on the river bank. These pumps are controlled by pH meter equipment which cuts out the pumps when the pH of the river is below 6·5. The river water is not suitable for immediate use and is passed into six clarifier tanks after being injected with a mixture of ferrous sulphate and lime solutions to promote flocculation, the resulting sludge being removed from the bottom of the tanks. The make-up cooling water is generally maintained at a pH value of 8·5.

In the centre of the station building and located on the operating floor is the control room which is completely sound-proofed with insulated cavity walls, double-glazed windows and revolving doors, and is also equipped with an air conditioning plant. In this room, part of which is illustrated opposite, are the combined unit control panels for the boilers and turbines, while the loading and logging desks in the centre of the room control all the electrical synchronising and loading of the turbo-alternators and the switching of the 66kV circuit breakers. There is a central alarm panel covering all sections of the plant. However, running up and shutting down of the turbines is carried out from the turbine floor.

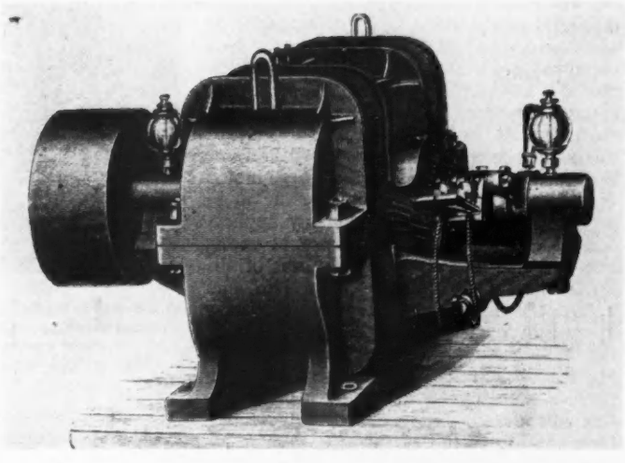
The 3300V supplies from the 66,000V substation are provided by two 7500kVA, 66/3·3kV transformers, which are oil cooled by natural circulation, have off-load tap changing with a total range of ±5 per cent in steps of 2·5 per cent. Each feeds one 3·3kV station board, which consists of air-break, truck-pattern switchgear of 150MVA rating, controlling all large motors. The trucks are located in cubicles having front doors and each switch is provided with integral earthing switches and isolation can be achieved by the withdrawal of plug contacts without the circuit breaker truck having to be withdrawn. The 415V auxiliary supplies are obtained via two 1500kVA, 3·3kV/415V transformers, which are connected on the high-voltage side, one to each station board, and feed a 415V station auxiliary board. This is arranged in two sections with a paralleling section switch which is interlocked so that it cannot be closed if both the infeeding transformer 415V switches are closed. The outdoor 66kV switching station, illustrated opposite, has nine outgoing lines, two of which feed into the 132kV substation at Llantarnam and one the Upper Boat power station 66kV system, while the remainder are Area Board distribution circuits. The station, which is of double-busbar, outdoor pattern, carried on reinforced concrete structures, has fourteen 1500MVA bulk oil circuit breakers installed with provision for the addition, if required, of a further two circuit breakers.

PRINCIPAL CONTRACTORS

Consulting civil engineers, Sir Bruce White, Wolfe, Barry and Partners; executive architect, Sir Percy Thomas; consulting plant engineers, Kennedy and Donkin; foundations and superstructure, Sir Robert McAlpine and Sons (South Wales), Ltd.; site investigation, George Wimpey and Co., Ltd.; piling, A. Waddington and Son, Ltd.; main steelwork, Braithwaite and Co. Structural, Ltd.; cooling towers, Film Cooling Towers (1925), Ltd.; chimney, J. L. Kier and Co., Ltd.; water tanks, Robert Watson and Co., Ltd.; cranes, The Wharton Crane and Hoist Company, Ltd., Herbert Morris, Ltd.; turbo-alternator plant, C. A. Parsons and Co., Ltd.; boilers, fuel equipment, ash and dust plant, Babcock and Wilcox, Ltd.; air heaters, James Howden and Co., Ltd.; draught fans, Davidson and Co., Ltd.; coal handling plant, precipitators, Simon-Carves, Ltd.; boiler dampers, Automotive Products Company, Ltd.; automatic boiler control system, Electroflo Meters Company, Ltd.; high-pressure steam and feed valves, Dewrance and Co., Ltd.; feed pumps, Sulzer Brothers (London), Ltd.; feed water make-up plant, Permutit, Ltd.; circulating water plant, Mather and Platt, Ltd.; circulating water make-up plant, Candy Filter Company, Ltd.; auxiliary pumps, Gwynnes Pumps, Ltd.; chlorination plant, Wallace and Tiernan, Ltd.; wagon tipplers, Strachan and Henshaw, Ltd.; electric motors, Lancashire Dynamo and Crypto, Ltd., Mather and Platt, Ltd., English Electric Company, Ltd., and Metropolitan-Vickers Electrical Company, Ltd.; circulating water valves, J. Blakeborough and Sons, Ltd.; 66kV, 3·3kV, 415V switchgear, control panels, English Electric Company, Ltd.; 415V contactor switchgear, Watford Manufacturing and Electric Company, Ltd.; generator transformers, C. A. Parsons and Co., Ltd.; station transformers, British Thomson-Houston Company, Ltd.; station auxiliary transformer, South Wales Switchgear, Ltd.; metering, Ferranti, Ltd.; 66kV overhead lines, J. L. Eve Construction Company, Ltd.; 66kV cable, Pirelli General Cable Works, Ltd.

Seventy-Five Years of Dynamos and Motors

To mark the completion of three-quarters of a century as manufacturers of rotating electrical machines and apparatus, Laurence Scott and Electromotors, Ltd., has set up a permanent exhibition of its products at the Salhouse Road branch works, Norwich. Among the products in which the company has specialised are variable-speed a.c. commutator motors, high-torque, low-current, squirrel-cage motors, crane and winch control systems and alternators with very close regulation. Below we outline some of the stages in the company's history and refer briefly to some of the equipments demonstrated in the exhibition.



SEVENTY-FIVE years ago William Hardy Scott built his first dynamo in the City of Norwich. Last month the company which he founded in 1883 opened a permanent exhibition of its modern variable speed electrical drives at its Salhouse Road Branch. This exhibition demonstrates some of the company's contributions to the precise control of rotating electrical machinery and one cannot study these exhibits without speculating about the growth and progress of the company over three-quarters of a century. A short history of the firm is given in a booklet, *Scott Built a Dynamo*, published by Laurence Scott and Electromotors, Ltd. Amongst other things it provides an interesting insight into the origins of the company and the way it has developed.

It is recalled, for example, that William Scott was working in Norwich for his employers, the Hammond Electric Light Company, in 1883. He was, in fact, fitting a new lighting system in Colman's works, but he was very dissatisfied with the construction and reliability of the machines he was installing. This critical attitude towards the lighting plant provides the key to his career and the policy of the firm he established with the encouragement and financial help of Colman. In partnership with a Mr. Paris he set up in business making dynamos in rented premises in Norwich. Soundness of construction and reliability were his aims; for example, all armatures were slotted and carefully wound and insulated and special care was given to lubrication of bearings. Our first illustration shows Paris and Scott's dynamo of 1883.

Five years later another engineer, Mr. Reginald Laurence joined the firm as a partner. Shortly afterwards Paris left and the business took the title Laurence Scott and Co. By 1896 the original premises had become too small for the firm's business and new works were built at Hardy Road. To broaden the local market for electric motors Scott started electricity supply undertakings in Norwich and Ipswich and he initiated reduced tariffs for "off-peak" loads, for which he designed a two-rate meter controlled by pilot wires from the power station. As these activities grew, however, it soon became necessary to concentrate on manufacture; the installation side of the business was sold to Mr. G. N. C. Mann, the founder of what is now Mann Egerton and Co., of Norwich.

While there was a growing demand for motors Scott's factory was also very busy building generators for central stations. By about 1898 the company was in a position to make all the equipment for electricity supply undertakings from the generating plant to the distribution mains.

Some of these mains were of bare copper strip laid in stoneware ducts. It was recorded in THE ENGINEER in 1896 that "In Norwich there are nearly seven miles of conduits with bare copper mains in them and there has been only one explosion"—and that, incidentally, was attributed to a leak from a gas pipe!

By the end of the century the firm had a footing in marine engineering, with a combined engine and generator set called the "Norwich Shiplighter." Initially these sets were made wholly in Norwich, but later, in association with Reavell and Co., Scott

developed a special marine engine. At about this time electric motors began to be used more widely. A catalogue of 1901 sets out the attributes of "Norwich" four-pole electric motors having "former-wound armatures, high-permeability steel magnet cores and frames that can be supplied either (1) well ventilated, (2) with gauze grids or (3) totally enclosed." All parts of these motors were "made to jigs and interchangeable." Having come to the notice of the Admiralty the company was soon engaged in making motors and control gear for ammunition hoists, windlasses and turret-turning gear on the immediate predecessors of the "Dreadnought."

After the war the interest in motor ships brought new marine electrical business and in the 1920s the company installed about 4000 h.p. of motors in the "Empress of Britain."

In 1923 Reginald Laurence died and four years later the company was amalgamated with Electromotors, Ltd., of Manchester. To keep in step with the gradual changeover from d.c. to a.c. supply the company (which was known, for short, as L.S.E.) was reorganised for the quantity production of standard a.c. motors. L.S.E. pioneered the development of welded steel frames for motors and adopted this form of construction. In 1935 the firm suffered another personal loss with the death of W. H. Scott.

Generally L.S.E. policy was for the smaller machines to be highly standardised and made in the Manchester factory while the Norwich works concentrated on the larger machines and "specials." For example, in 1939 the company began to develop the N-S variable-speed a.c. commutator motor, which provided stepless speed variation, with manual or automatic control and without movement of brushgear. Another pre-war innovation was the company's "Trislot" high-torque, low-current, squirrel-cage motor which was designed to supersede the more expensive slipring motor for many applications. These products are the first of a long line of contemporary manifestations of the firm's will to specialise. The N-S and "Trislot" motors are truly contemporary in that they, and their derivatives such as the "Speedmaster" frequency converter, are still technically and commercially competitive twenty years after the first of them was introduced. It is these products that form the framework of the exhibition which is briefly described below.

While the company's interests in motors and other rotating machinery leaned towards increasing specialisation, the Thorpe Road works began, after the war, to concentrate on a range of standardised a.c. and d.c. control gear instead of the "tailor-made" products which had constituted the majority of its work. Thorpe Road, however, continued to meet the more specialised requirements of control gear for the firm's variable speed and multi-motor drives.

The post-war expansion included the opening of a new instrument works for mechanisms and assemblies of the kind used in Services fire-control instruments. To allow for the building of larger motors than hitherto, new machine tools and a new impregnating plant were installed at the Gothic works. This year a new bay has been built and is being equipped for the manufacture of motors ranging from 2000 h.p. to 9000 h.p.

Exhibition of L.S.E. Products

The exhibition at Salhouse Road is designed to typify the wide variety of L.S.E. equipment having special characteristics developed for industrial and marine applications. Variable-speed a.c. and d.c. motors are prominent among the working exhibits, which include several variants of the N-S motor and Ward Leonard variable-speed motors with the associated speed-control systems. "Trislot" high-torque, low-current squirrel-cage motors, crane and winch drives, and alternators with closely controlled regulation are also demonstrated. Some of the exhibits can be seen in the accompanying illustration.

The N-S motor, it will be recalled, is a stator-fed, variable-speed a.c. motor, the speed of which can be adjusted smoothly over a wide range under all loading conditions, without brush movement. Three methods of direct speed control are exhibited.

A permanent exhibition of the products of Laurence, Scott and Electromotors, Ltd., has been set up at the company's branch works, Salford Road, Norwich. Part of the exhibition is shown here. In the foreground are scale model working winches and a demonstration of the "Revcon" control system for crane hoist systems. On the right are demonstrations of variable speed industrial a.c. motors and automatic control gear

The first is a hand-operated induction regulator; pilot motor operation of the regulator is a frequently used alternative. The second is a joystick-operated regulator, which is an effective means of controlling small cranes and hoists, with inching control and rapid stopping by regeneration or "plugging," the speed being determined by the angular movement of the joystick from the central "off" position. The third method is by a tapped transformer (instead of an induction regulator) giving four preset speeds, with a "Variac" transformer for small speed variations. This system is often useful when rapid speed changes are required. It is applied to the driving motor (rated at 9/1 h.p. at 2250/250 r.p.m.) of a plate curving machine in the company's Gothic works.

One refinement of the basic arrangement is to apply an electronic ("Velonic") control system to give an accurate preset speed with precise speed control of the N-S motor. Speed control is obtained by comparing a d.c. reference voltage (obtained from an electronic stabiliser) with the output from a tachogenerator mechanically coupled to the motor shaft. Three decade-resistance settings form part of the tachogenerator summing network and are arranged so that the ratio of the summing network is changed when the value of the preset speed is changed. The error signal from the summing network, which is a measure of the difference between the desired and actual speed, is fed into a d.c. amplifier and thence to two opposing field windings of a d.c. servo-motor which turns the induction regulator of the N-S motor until the latter runs at the desired speed. A tachogenerator mechanically coupled to the servo-motor provides the velocity feed-back voltage which stabilises the system and eliminates any tendency to hunt.

A special compensating network incorporated in the equipment automatically compensates for the small speed changes which are normally caused by temperature and brush drop variation in the tachogenerator. This provision enables the equipment to be run for long periods with a very low speed tolerance and considerably increases the accuracy of speed setting. It is claimed that small day-to-day variations on preset speed which are normally inherent with this kind of speed control have been virtually eliminated. The equipment is designed to control the speed of the motor to within approximately ± 2 r.p.m. over the speed range, irrespective of supply voltage and/or frequency variations of ± 10 per cent and load variations from zero to full load.

In another demonstration, the automatic control speed device takes the form of an "Asrec" control equipment, which is a simple standardised system employing a sensitive polarised relay and stabilising circuits with a d.c. tachogenerator and potentiometer for the signal and reference voltages respectively. This system is designed to maintain a speed of the required value under varying load and supply conditions with a "steady state" accuracy of ± 1 per cent; for machines with a wide speed range (say, 10 : 1) the accuracy, referred to bottom speed, is stated to be better than ± 5 per cent. This performance can be demonstrated by varying the load by means of a mechanical brake.

Alternator control is demonstrated by a self-excited alternator with "Altoreg"

control, driven from a " Trislot " motor and loaded by another " Trislot " induction motor, of 5 h.p., fitted with a mechanical brake. The " Altoreg " system employs two separate excitation windings, the main winding of the two being excited by the load current through a current-transformer/rectifier system. In its simplest form the alternator is made self-excited by supplying a second, auxiliary, winding from a rectifier connected across the output terminals. For self-excited machines a regulation of approximately ± 5 per cent throughout the rated load range is claimed with an extremely high-speed response. The former characteristic is demonstrated by varying the load on the motor supplied from the alternator (by use of the mechanical brake) and the latter by switching the motor direct on to the alternator. The loading motor is a 5 h.p., 1000 r.p.m. " Trislot " motor, designed to take a starting current of about three and a half times full-load current and to develop one and a half times full-load torque.

Load sharing and variable-speed control applied to standard squirrel-cage motors is demonstrated by means of the " Speedmaster " system. The " Speedmaster " is a single-unit converter for supplying variable frequency a.c. current ; its main use is for the operation and control of variable-speed squirrel-cage motors. The machine, based on the N-S variable-speed a.c. motor, comprises a stator of normal design and a rotor provided with both commutator and sliprings. The speed of the set is controlled by an induction regulator connected to the commutator, alternating current at a frequency and voltage varying with the speed being delivered at the sliprings. Frequency control may be effected by hand, push-button or automatic device, as for the N-S motor. The machine exhibited is housed with all control equipment in a " packaged " unit. For the demonstration, eight squirrel-cage motors of different sizes, fitted with tachometer indicators and ammeters, are supplied from the " Speedmaster " to show four main characteristics : stepless, simultaneous speed variation ; effective load sharing ; smooth starting; and " plug " reversing.

Two typical applications of low-frequency supply from a frequency converter are exhibited. In the first four motors forming a section of a roller table drive are supplied at low frequency and at low voltage (approximately 3 c/s, 55V) and provide direct drive at 60 r.p.m.; the use of low frequency has important operational advantages for drives involving frequent starting, stopping, continuous stalling, plugging and reversal. It enables a low speed to be obtained without mechanical gearing. Mechanically, the motors are of " floating " construction, which substantially isolates the motor from mechanical shocks and vibration transmitted from the roll or other driven unit and from the effects of misalignment or a distorted roll.

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developed a special marine engine. At about this time electric motors began to be used more widely. A catalogue of 1901 sets out the attributes of "Norwich" four-pole electric motors having "former-wound armatures, high-permeability steel magnet cores and frames that can be supplied either (1) well ventilated, (2) with gauze grids or (3) totally enclosed." All parts of these motors were "made to jigs and interchangeable." Having come to the notice of the Admiralty the company was soon engaged in making motors and control gear for ammunition hoists, windlasses and turret-turning gear on the immediate predecessors of the "Dreadnought."

After the war the interest in motor ships brought new marine electrical business and in the 1920s the company installed about 4000 h.p. of motors in the "Empress of Britain."

In 1923 Reginald Laurence died and four years later the company was amalgamated with Electromotors, Ltd., of Manchester. To keep in step with the gradual changeover from d.c. to a.c. supply the company (which was known, for short, as L.S.E.) was reorganised for the quantity production of standard a.c. motors. L.S.E. pioneered the development of welded steel frames for motors and adopted this form of construction. In 1935 the firm suffered another personal loss with the death of W. H. Scott.

Generally L.S.E. policy was for the smaller machines to be highly standardised and made in the Manchester factory while the Norwich works concentrated on the larger machines and "specials." For example, in 1939 the company began to develop the N-S variable-speed a.c. commutator motor, which provided stepless speed variation, with manual or automatic control and without movement of brushgear. Another pre-war innovation was the company's "Trislot" high-torque, low-current, squirrel-cage motor which was designed to supersede the more expensive slipring motor for many applications. These products are the first of a long line of contemporary manifestations of the firm's will to specialise. The N-S and "Trislot" motors are truly contemporary in that they, and their derivatives such as the "Speedmaster" frequency converter, are still technically and commercially competitive twenty years after the first of them was introduced. It is these products that form the framework of the exhibition which is briefly described below.

While the company's interests in motors and other rotating machinery leaned towards increasing specialisation, the Thorpe Road works began, after the war, to concentrate on a range of standardised a.c. and d.c. control gear instead of the "tailor-made" products which had constituted the majority of its work. Thorpe Road, however, continued to meet the more specialised requirements of control gear for the firm's variable speed and multi-motor drives.

The post-war expansion included the opening of a new instrument works for mechanisms and assemblies of the kind used in Services fire-control instruments. To allow for the building of larger motors than hitherto, new machine tools and a new impregnating plant were installed at the Gothic works. This year a new bay has been built and is being equipped for the manufacture of motors ranging from 2000 h.p. to 9000 h.p.

Exhibition of L.S.E. Products

The exhibition at Salhouse Road is designed to typify the wide variety of L.S.E. equipment having special characteristics developed for industrial and marine applications. Variable-speed a.c. and d.c. motors are prominent among the working exhibits, which include several variants of the N-S motor and Ward Leonard variable-speed motors with the associated speed-control systems. "Trislot" high-torque, low-current squirrel-cage motors, crane and winch drives, and alternators with closely controlled regulation are also demonstrated. Some of the exhibits can be seen in the accompanying illustration.

The N-S motor, it will be recalled, is a stator-fed, variable-speed a.c. motor, the speed of which can be adjusted smoothly over a wide range under all loading conditions, without brush movement. Three methods of direct speed control are exhibited.

A permanent exhibition of the products of Laurence, Scott and Electromotors, Ltd., has been set up at the company's branch works, Salford Road, Norwich. Part of the exhibition is shown here. In the foreground are scale model working winches and a demonstration of the "Revcon" control system for crane hoist systems. On the right are demonstrations of variable speed industrial a.c. motors and automatic control gear

The first is a hand-operated induction regulator; pilot motor operation of the regulator is a frequently used alternative. The second is a joystick-operated regulator, which is an effective means of controlling small cranes and hoists, with inching control and rapid stopping by regeneration or "plugging," the speed being determined by the angular movement of the joystick from the central "off" position. The third method is by a tapped transformer (instead of an induction regulator) giving four preset speeds, with a "Variac" transformer for small speed variations. This system is often useful when rapid speed changes are required. It is applied to the driving motor (rated at 9/1 h.p. at 2250/250 r.p.m.) of a plate curving machine in the company's Gothic works.

One refinement of the basic arrangement is to apply an electronic ("Velonic") control system to give an accurate preset speed with precise speed control of the N-S motor. Speed control is obtained by comparing a d.c. reference voltage (obtained from an electronic stabiliser) with the output from a tachogenerator mechanically coupled to the motor shaft. Three decade-resistance settings form part of the tachogenerator summing network and are arranged so that the ratio of the summing network is changed when the value of the preset speed is changed. The error signal from the summing network, which is a measure of the difference between the desired and actual speed, is fed into a d.c. amplifier and thence to two opposing field windings of a d.c. servo-motor which turns the induction regulator of the N-S motor until the latter runs at the desired speed. A tachogenerator mechanically coupled to the servo-motor provides the velocity feed-back voltage which stabilises the system and eliminates any tendency to hunt.

A special compensating network incorporated in the equipment automatically compensates for the small speed changes which are normally caused by temperature and brush drop variation in the tachogenerator. This provision enables the equipment to be run for long periods with a very low speed tolerance and considerably increases the accuracy of speed setting. It is claimed that small day-to-day variations on preset speed which are normally inherent with this kind of speed control have been virtually eliminated. The equipment is designed to control the speed of the motor to within approximately ± 2 r.p.m. over the speed range, irrespective of supply voltage and/or frequency variations of ± 10 per cent and load variations from zero to full load.

In another demonstration, the automatic control speed device takes the form of an "Asrec" control equipment, which is a simple standardised system employing a sensitive polarised relay and stabilising circuits with a d.c. tachogenerator and potentiometer for the signal and reference voltages respectively. This system is designed to maintain a speed of the required value under varying load and supply conditions with a "steady state" accuracy of ± 1 per cent; for machines with a wide speed range (say, 10 : 1) the accuracy, referred to bottom speed, is stated to be better than ± 5 per cent. This performance can be demonstrated by varying the load by means of a mechanical brake.

Alternator control is demonstrated by a self-excited alternator with "Altoreg"

control, driven from a " Trislot " motor and loaded by another " Trislot " induction motor, of 5 h.p., fitted with a mechanical brake. The " Altoreg " system employs two separate excitation windings, the main winding of the two being excited by the load current through a current-transformer/rectifier system. In its simplest form the alternator is made self-excited by supplying a second, auxiliary, winding from a rectifier connected across the output terminals. For self-excited machines a regulation of approximately ± 5 per cent throughout the rated load range is claimed with an extremely high-speed response. The former characteristic is demonstrated by varying the load on the motor supplied from the alternator (by use of the mechanical brake) and the latter by switching the motor direct on to the alternator. The loading motor is a 5 h.p., 1000 r.p.m. " Trislot " motor, designed to take a starting current of about three and a half times full-load current and to develop one and a half times full-load torque.

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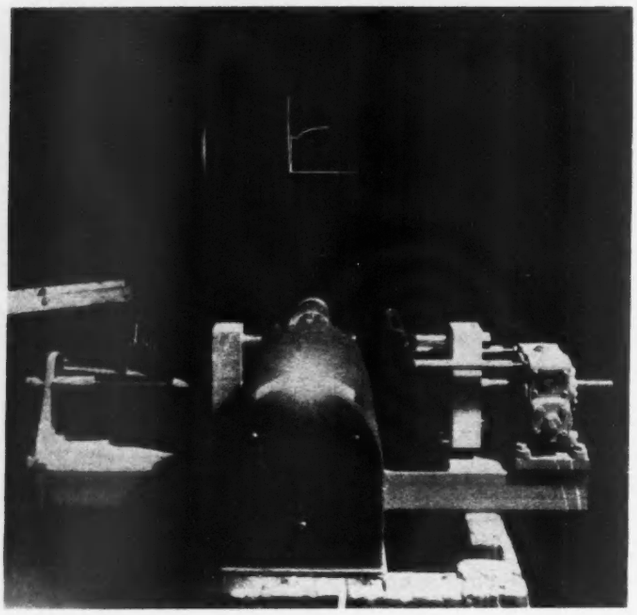
Tensile Testing Machine with Recording and Projecting Attachments

A TENSILE testing machine of interesting design has recently been developed by Professor J. A. Pope, of the University of Nottingham, and made by Tecquipment, Ltd., of 79, Alfreton Road, Nottingham. The machine is principally intended for use in engineering and technical colleges and similar establishments, and is designed to record the progress of a tensile test on a specimen, in the form of a continuous graph, traced by a stylus on a smoked glass plate. The equipment incorporates a built-in projector which enables an enlarged image of this graphic record to be projected on a screen that permits the behaviour of a specimen throughout a test cycle to be displayed to a group of observers.

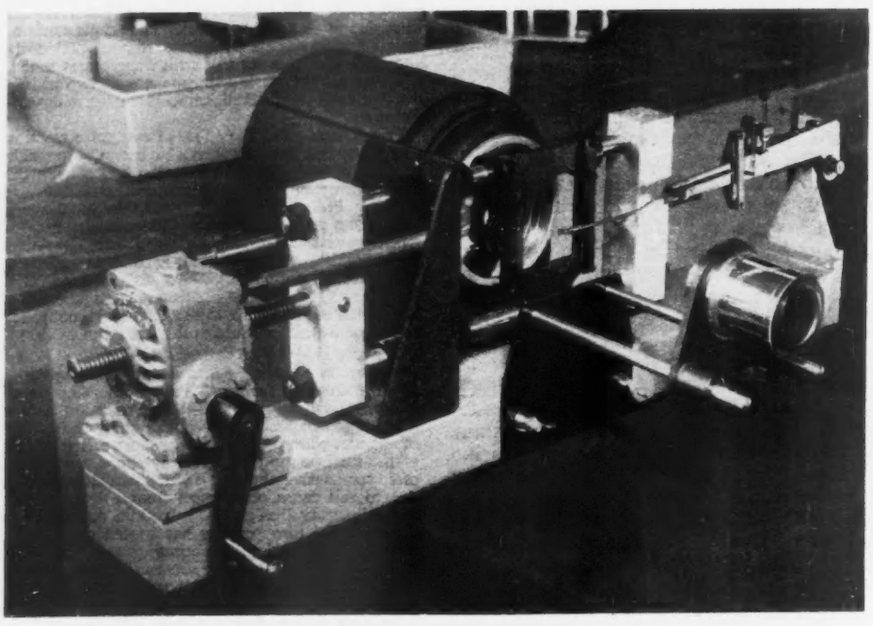
The machine, as can be seen from the illustration, is of simple construction. Its base plate is a length of steel channel and has an A-shaped steel anchor plate bolted to one end. This anchor plate, which is designed to provide a precise degree of resilience, projects up from the base plate, and near its upper end carries an internally threaded coupling sleeve into which the anchored ends of test specimens are screwed. The sleeve is linked to the anchor plate by a combined knife edge and spherical fitting, which obviates bending stresses on the specimen during tests.

On the opposite end of the base plate is a tensioning unit, consisting of a standard "Radicon" worm gear, which is modified by the fitting of an internally threaded sleeve in the centre of the worm wheel, and the replacement of the worm wheel spindle by a correspondingly threaded rod. The rotation of the worm by a small handle causes the threaded rod to move in a direction parallel to the axis of the worm wheel. The inner end of the threaded rod is attached to the centre of a vertical steel bar forming a crosshead, from which steel rods pass across the machine to a similar crosshead at the anchor plate end of the base plate.



Tensile testing machine shown in operation with graph projected on screen

The centre of the second crosshead is fitted with an internally threaded coupling sleeve, similar to that at the anchor plate end, into which the tensioned end of the specimen to be tested is screwed. This sleeve is also carried by a self-aligning bearing to prevent bending stress on the specimens.



Tensile testing machine from tensioning end, showing slide frame stylus and projection attachment

Spanning the two bars that link the crossheads is a small frame, similar to a lantern slide carrier, and into grooves in this frame there can be inserted the piece of smoked glass sheet on which the record of the test is made. The frame is adjustable, and it can be moved along the bars to a suitable position for projection and locked by a small thumb-screw.

To ensure that the two crossheads and their coupling bars remain in correct alignment, the bars pass through sleeve guides mounted in a bracket attached to the base plate near the tensioning worm gear. To further ensure rigidity, two stiffening rods are fitted between the bracket and the worm gear housing.

The stylus used for making the record of the test on the smoked glass panel is mounted on a calibrated cantilever arm attached to the upper end of the anchor block. This arm, which is parallel to the tensioning assembly, carries a second, lighter, arm on its outer side, and on an adjustable grip on this second arm the stylus bar is mounted.

So that the second arm can have a small amount of movement relative to the main arm, it is provided with an adjusting screw, and is spring loaded. With this form of mounting, adjustments can be made to the position of the stylus point to bring it to the desired position on the glass panel before the start of the test, and to enable the glass plate to be marked in definite increments of load. The adjusting screw and the calibrated cantilever arm are so designed that each turn of the screw produces a deflection of the stylus point equal to a definite number of tons.

When a test is to be carried out, a specimen piece of metal, machined to size and suitably threaded, is put into position and firmly screwed home into each sleeve. A smoked glass panel is then inserted in the carrier frame, and the stylus adjusted to a position near the top left-hand corner of the panel. The stylus point is set at an offset angle, as mentioned above, to prevent its shadow and that of its arm obscuring the clarity of the projected image.

As tension is applied to the specimen by the turning of the operating handle, the frame and glass, being mounted on the tensioning assembly, is moved towards the worm gear end of the machine. Tension is transmitted through the specimen to the anchor plate and causes the plate to bend inwards slightly. This movement of the plate depresses the point of the stylus. These two concerted movements result in the scribing of a graph on the smoked glass, and, as the tension which causes the deflection of the anchor plate is transmitted through the specimen under test, it results in a continuous graph illustrating the behaviour of the specimen up to the breaking point.

The projection equipment, which really forms an adjunct to the testing machine, consists of a lamp house and condenser lenses at the back of the machine, and a normal arrangement of projection lenses, mounted on a frame attached to the front of the machine.

Light from the lamp is projected on the glass panel, and the line of the graph then appears as a line of light projected by the other lens assembly on to a screen, as shown in the upper illustration.

Vertical and horizontal lines, intersecting at the point where the stylus commences its graph, are scribed on the smoked coating of the glass before the test begins. Other information, such as the details of the specimen to be tested, can also be marked on the panel for projection on the screen.

During a test, the gradual development of the graph is interesting to watch, and small variations in the graph curve, which might be missed in normal plotting of such a curve from successive readings, show up very clearly. In the tests on several specimens which we have seen demonstrated, early yield and recovery characteristics were quite apparent.

Another interesting point with the equipment is that it enables tensile loading to be removed at any stage in a test, and this results in a vertical line being made on the graph. Reimposition of the load then usually results in the stylus returning over the vertical line to the point where it intersects with the graph curve, and then continuing with the curve proper as the load is increased.

A graphic record can be made by spraying the smoked surface of the glass with a colourless lacquer.

SHORTER REPORTS

Preliminary Studies for the Channel Tunnel

SOME details have been received of the progress made by the Channel Tunnel Study Group in its investigations of the channel tunnel project. The Group was formed in 1957 from the English Channel Tunnel Company, the French Channel Tunnel Company and the International Road Federation (Paris Office), the Suez Company and an American company, Technical Studies Inc., and is spending £200,000 on a two year programme. The first and most important point to be investigated was considered to be the nature of the ground to be tunnelled through. Upon this depends the feasibility of the project, as the British consulting engineers emphasised in their reports of 1929 and 1947. A considerable amount of work was done up till 1880, when the project was very much alive ; and a report exists of an extensive survey made from the French side.

An experimental seismic survey has been carried out on each side of the coast. Diamond drilling up to 600ft deep has been carried out on both sides producing continuous cores of about 4½in diameter all the way through the middle and lower chalk, Gault and Greensand formations. This work was done by the Craelius Company. In addition geophysical investigations were made along the surface adjacent to these borings, so that the instrumental records could be checked for accuracy with the borehole. The results of this seismic work are now being interpreted so as to ascertain whether the contrasts in the various strata are clear enough to make it worthwhile carrying out such work in the Channel itself. A sonar survey has also been carried out by the Telephonics Corporation of New York. It was found that when travelling with the transducer close to the surface, penetrations of 100ft below the sea-bed were recorded, while when the transducer was dropped to the bottom the penetration was over 500ft in the chalk and about 1000ft in the rocks below the chalk. Interpretation of the sonar records will take some little time, but preliminary interpretations have shown a remarkable agreement with the 1875 map, it is stated. Whilst it is too early to draw any categorical conclusion, the Group considers, it can be said that this preliminary sonar survey does not seem to have disclosed any faults in structure which would constitute an insuperable obstacle to the construction of a tunnel.

Samples from the sea-bed were obtained by divers of the French firm, Sogetram, on the French side, and by Universal Divers, Ltd., on the British side. As well as these investigations, the French firm Fougerolle was given the work of pumping out and examining the shaft and pilot tunnel at Sangatte, which had been submerged since 1883. The old pilot tunnel was found to be in remarkably good condition.

The next steps to be undertaken are to complete the interpretation of this year's survey and to prepare for the next season's work, when it is hoped to complete the Study Group's programme by carrying out some borings through the Channel bed. This will enable the results of geophysical exploration to be checked. It may also be necessary to do some additional geophysical work to fill any gaps in knowledge acquired by this year's work. All this geophysical investigation is required primarily to establish the best route, but it will also provide information for the next stage of the work—namely engineering studies to determine the best methods of construction and the approximate cost of a rail or road tunnel or both.

For investigating the soundness of the tunnel as an economic proposition the Economist Intelligence Unit of London, a French company S.E.T.E.C., and De Leuw Cathers Company of Chicago have been entrusted with the task of investigating the pattern of trade with the continent, the existing transport costs, passenger and motor-car traffic, the incidence of customs and immigration delays, tolls and other relevant factors. They are also to make forecasts, based on available statistics, of future trends, including the increase of traffic which the provision of the tunnel in several alternative forms is likely to stimulate. This work was begun during the summer.

British and Russian Steel Research

A SMALL group of Russian scientists, led by Academician Bardin, vice-president of the Soviet Academy of Sciences, is expected to visit this country early next month to study iron and steel research here. The tour will last from ten to fourteen days and will include visits to the British Iron and Steel Research Association's laboratories in London, Sheffield, Swansea, and possibly Normanby, together with a number of works visits. The arrangements are being made by B.I.S.R.A. in conjunction with the Iron and Steel Institute.

Steps towards closer and more detailed co-operation between Russia and Great Britain were initiated when a British team visited the U.S.S.R. recently to study Soviet research on steel technology and related subjects. This visit arose out of earlier and broader exchanges between iron and steel delegations : after the visits by representatives of the British Iron and Steel Federation in 1955 and 1956 and the return visit by Russian experts in 1956 it was felt that exchanges between more specialised groups would be valuable. The chief object of the recent visit of the British team to the U.S.S.R. was to study the organisation of iron and steel research in the Soviet Union.

The British team, which was headed by Sir Charles Goodeve, director of B.I.S.R.A., spent eight days in the U.S.S.R. In Moscow visits were made to the Central Research Institute of Ferrous Metallurgy, the Baikov Institute, which is the Metallurgical Institute of the Soviet Academy of Sciences, and other research organisations. Outside Moscow the team visited the experimental factory at Novo Tulsky, about 100 miles from the capital. The team says that iron and steel research in the U.S.S.R. is being carried out on a very extensive scale and is roughly comparable in standard with similar research being carried out elsewhere. The outstanding feature is the speed with which results are applied. This is especially true of continuous casting, in which the Russians are certainly ahead of most other countries. Their research is going ahead rapidly, and in addition to the five plants already operating commercially two new plants are in an advanced stage of construction. One of these is being installed in a new works which will have no primary rolling-mills. A great deal of work is also being done in Russia on vacuum-treatment of steels to remove dissolved gases. In one simple but apparently effective process that has been developed a 50-ton ladle of steel is de-gassed in ten or fifteen minutes by two-stage pumping ; the power required is about 250kW. This process is being used for steels for transformers and aircraft. According to members of the team, continuous casting and vacuum-treatment are undoubtedly the highlights of current Russian research, but it was also possible to see some interesting work which is being carried out on such subjects as ultrasonic grain-refining of castings, electrostatic lacquering of blackplate and electron-probe analysis.

The visit confirmed that the Russians are a force to be reckoned with in iron and steel research. As would be expected, they are ahead of the United Kingdom in some spheres while the United Kingdom is ahead of them in others. The team's report adds that the way has been cleared for further and more detailed exchanges, which will certainly be to the benefit of both countries.

Two Steel Strip Mills

GOVERNMENT approval of two steel strip mill projects was announced in Parliament on Tuesday by the Prime Minister, Mr. Harold Macmillan. He said the Government had accepted the conclusion of the Iron and Steel Board that additional capacity for the production of strip mill products was required to meet the future needs of the national economy. It had been decided, in principle, that this additional capacity should include two major strip mill projects each with appropriate steel-making and finishing capacity. The Government had decided to issue an industrial development certificate for one project to be undertaken by Richard Thomas and Baldwins, Ltd., at Newport, Mon, which would represent the first stage of a major expansion of strip mill production in South Wales. Its precise nature, timing and financing were under discussion between the interested parties, including the company and the Iron and Steel Board, but it was envisaged that the initial production capacity would be of the order of 500,000 tons for sheet and tinplate. It was not yet possible to give an estimate of the cost.

The Prime Minister went on to say that the board of Colvilles, Ltd., had agreed in principle to undertake the other project in association with its new Ravenscraig works at Motherwell, and the existing works at Gartcosh, both in Lanarkshire. The Government was prepared to grant an industrial development certificate for that purpose. It was intended that the project, which included modernisation of existing plant, should have an initial productive capacity of approximately 500,000 tons for sheet and light plate. It would make use of facilities already being provided by Colvilles, Ltd., and the additional cost was estimated at about £50,000,000. The initial capacity for sheet would represent a surplus above present Scottish consumption and would, it was hoped, attract to Scotland new industries using sheet.

The Prime Minister added that both projects would be capable of substantial extensions, particularly that in South Wales. To the extent that their construction would require funds additional to the resources of the two companies, the necessary amounts would be advanced to them by the Government. Details of the final arrangements would be made available in due course.

Use of Radioisotopes in Underground Gasification Scheme

RADIOISOTOPES are being used to assist in overcoming a number of problems in connection with the development of the pilot plant for the underground gasification of coal projects which are being performed by Humphreys and Glasgow, Ltd., of London, for the National Coal Board at Newman Spinney, near Chesterfield. In one application the radioisotope Krypton 85 as a tracer gas has been injected into an air stream to determine the position of leakage in underground piping. It has similarly been used to indicate the rate at which coal is being gasified underground, the occurrence of subsidence of roofing or the merging of two borehole fires. In checking

suspected leakage, the air stream is injected with Kr^{85} and pipes to the fires below. During and after gasification, gas returns to the surface along the same shaft ; monitoring begins immediately at the surface for the return of radioactive gas. If there is no leak, radioactivity is monitored as a single pulse, but if a leakage exists, a small quantity of radioactivity is monitored ahead of the main pulse—assuming that the leak is subsidiary to the main flow. Calculations are then made to locate the position and magnitude of leakage.

Accurate drilling of a vertical borehole to intersect a horizontal one was found to be difficult with available survey methods and the problem was solved by using the radioisotope Cobalt 60. In this work, a full-sized horizontal hole is drilled and a small diameter vertical hole sunk to the expected location for intersection. If this intersection is missed, a source of gamma radiation is placed in one borehole and a counter in the other. Radiation is then transmitted through the coal barrier and measured; by comparing this value with known standards, already determined, the separation can be found and intersection achieved.

Another problem has been the accurate directing of a drilling bit along a seam where deviations due to irregular strata cause wastage in time and labour. The general layout of coal strata having previously been discovered by vertical and horizontal drilling, an instrument using radioactive cobalt and developed by the Mining Research Establishment of the National Coal Board is used to give warning if the drilling bit is in danger of leaving the coal seam.

The variation in the amount of natural radioactivity occurring in different strata may be used to enable drilling to be kept on course. Clay, for example, contains up to three times more radioactivity than coal ; near the edges of the coal strata, therefore, a significant increase in radioactivity is recorded. When this occurs during directional drilling, the drill setting can then be modified to maintain the bit in the seam, an important development in underground gasification technique, which calls for boring horizontal holes of considerable length.

Laying Long Welded Rails

An interesting method of laying long welded rails in one continuous operation has been devised by the Chief Civil Engineer's Department of the North Eastern Region of British Railways. For this operation there is used a train of eleven "Salmon" type bolster wagons with a total length of about 700ft and on this train up to thirty-six welded rails, 300ft in length, can be loaded at the new rail welding depot at Dinsdale, near Darlington. Pairs of these rails are at present fishplated together to form 600ft lengths, although it is pointed out that eventually continuous welded rails 600ft long will be available. The rear wagon of the train has special gantry equipment which is designed to guide the lengths of rail off the wagons at the normal rail spacing of 4ft 8½in, and for lowering the rail ends.

Before starting laying in operations the two rail ends are anchored to the track by 60ft long wire ropes and the eleven wagons are drawn forward by a diesel-electric shunting locomotive until the first 70ft of each pair of rails is clear, and the ends of each length have been deflected down to the level of the rails in the track. During this part of the operation the first pair of short rails in the existing track are tipped out manually from the sleeper seatings. At this point the train is brought to a stand and the ends of the long rails are put into position in the vacant sleeper seatings. The ends of the long rails are then fishplated to the existing track and the wire ropes removed.

The train is then started and kept moving forwards at a constant speed of about 30ft a minute. As the train moves the short rails of the existing track are tipped out in pairs as the rear wheels of the last wagon move clear, and the 600ft rails are guided into their sleeper seatings by men using bars. When the free ends of the first pair of 600ft rails have reached a position on the wagon next to the gantry wagon, the train is stopped and the rails are coupled by fishplates to the second pair of 600ft lengths. This cycle of operations continues until the last pair of rails is being drawn off the wagon.

When only 2ft or 3ft of long welded rail remains to come through the last pair of rollers on the end wagon the train is stopped and the rail ends lifted just clear by chain blocks suspended from a lowering gantry. The train then moves forward a few feet and is stopped whilst the rail ends are lowered into their sleeper seatings. Portable telephone equipment is used to maintain communication for control between the engine and the gantry wagon of the train.

This method of installing long welded rails was employed on the East Coast main line between Beningbrough and Tollerton recently ; the section has been laid with 109 lb flat bottom rail on concrete sleepers.

Hydraulic Dredger

Last week, a novel floating dredger was demonstrated, by its makers, Acrow (Engineers), Ltd., South Wharf, London, W.2, on the Great Ouse River at St. Ives, in Huntingdonshire. The dredger is shown in the illustration above ; it is noteworthy for the employment of hydraulic principles such that the solid materials dredged by it do not pass through the impeller of a pump or through any other moving parts.

The "Jet" dredger. The head assembly shows the central suction pipe with water jets on each side, and the pump mains and central delivery main for dredged material above

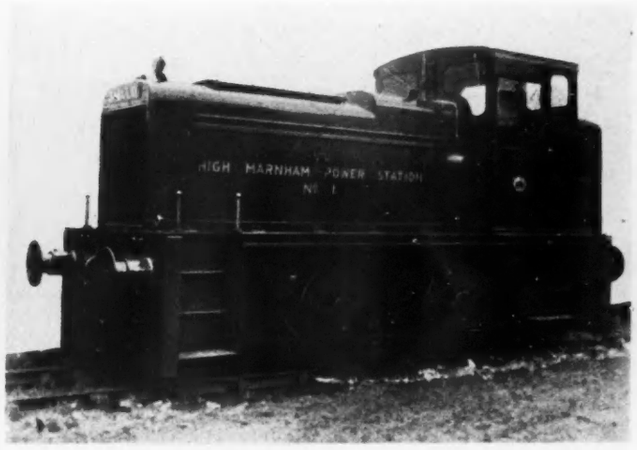
The working head of the dredger consists of a suction pipe, and two jetting heads, one on each side of it, as shown in the illustration. Jets of water disturb the material to be dredged, which is then drawn up the suction pipe. This "suction" is induced by connecting the top of the pipe to the throat of a venturi. The hydraulic circuit also can be clearly followed from the illustration. Water is drawn from the river by two pumps, which deliver respectively into each of the outer arms of the U-shaped pipe assembly shown suspended on a pulley at the front of the dredger. A branch pipe from each of these arms supplies the jetting heads, but most of the flow passes round the base of the "U" to the central pipe. The venturi is positioned in this central pipe, and, as already mentioned, the suction pipe is connected to its throat. The pressure/velocity distribution of flow through a venturi is well known, and needs no explanation here, save to point out that the low pressure at the throat entrains the flow of water, with the dredged material suspended in it, up the suction pipe. Beyond the venturi, the central, or "delivery" pipe, passes through the dredger and is carried by pontoons to the settling lagoons.

In the machine demonstrated at St. Ives a diesel-electric generating set of 160kW was mounted on the dredger, to power the two centrifugal pumps. These pumps were each driven by an 85 h.p. motor, and had a capacity of 1000 g.p.m. at the operating head of 75ft. The pumping mains forming the outer sides of the "U" were each 12in in diameter, and the delivery pipe was also 12in in diameter. The reduction at the venturi was from 12in to 8in, and the connection from the suction pipe was also 8in in diameter. Velocities of flow were stated to be 10ft/11ft per second in the delivery pipeline and close to 100ft per second at the throat of the venturi.

This particular machine had a capacity of 45 to 65 cubic yards per hour of solids delivered 600ft away at a height 6ft above the water level. Its maximum dredging depth was 35ft, but a depth of 100ft is considered feasible. The claim was made that any solid which could pass through the throat of the venturi could be handled and, in fact, large stones were placed in the suction pipe and passed through to the lagoon. It is further considered that the dredger can operate successfully when the bed material is a stiff clay, but the capacity drops to the region of 40 cubic yards of solids per hour.

The number and disposition of the jets of water at each jetting head may be adjusted and in practice are arranged so that a semi-circular "face" of material is formed, and subsequently worked by rotating the dredger about its stem, where the delivery pipe emerges. A crew of two is needed, and there is a control cockpit giving a view of the whole operation. At the demonstration gravel was dredged, but applications in alluvial mining, recovery of aggregates, and river and canal conservancy are considered equally promising. Larger capacities are possible, but the present design has not been developed for sea-going work. Emphasis has been placed on dismantling for easy transport. By comparison, a device operating on similar principles, but for the removal of ash from a power station sump, may be referred to in The Engineer of August 8 last, page 224.

An 800 gallon bag tank, fully loaded, on a Bedford 5-ton truck



302 h.p. diesel-hydraulic locomotive with a maximum tractive effort of 28,500 lb at 1½ m.p.h.

Collapsible Transport Tanks

In our account of the S.B.A.C. Exhibition (September 19, page 439) we recorded that Marston Excelsior, Ltd., had tested an 800 gallon "Portolite" tank for carriage on a 5-ton truck. Some details of this bag have now been made available; it is illustrated here. The tank is shown lashed down; this is always necessary if it is partly empty, but a full tank may be constrained simply by the sides of a truck body if they are strong enough. When the bag is empty it is rolled up and occupies virtually none of the capacity; by keeping it rolled until the filling hoses are connected, air is prevented from entering. The tank is filled until it attains a specified height. The tank can be emptied by gravity or pumping, and to get the last of the liquid out the parts of the tank remote from the valve and connector are lifted manually.

The material of the bag will be chosen to suit the contents; fabrics compatible with petrol, mineral oils, vegetable oils, water, latex, alcohols, detergents, molasses, ketones, esters, fruit juices, dilute acids, and salt and alkaline solutions are available. The bag can be cleaned with steam or detergent; a second hose fitting may be provided to assist in this process. Punctures, we are advised, can be repaired easily.

Apart from the value of collapsible tanks where a vehicle does not normally have a satisfactory load factor, it is noteworthy that they are far less difficult than a metal shell to mount on the flexible chassis favoured by vehicle makers to-day.

Buried Distribution Transformers

We learn that extensive field trials have been carried out in Scotland over the past twelve months on a new design of buried distribution transformers. The idea behind the trials is that the difficulties of finding new sites for transformers to reinforce existing supply networks could be eased by burying transformers at the load centres. Supply authorities would thus have a useful alternative to the conventional method of reinforcing networks by installing larger transformers to replace existing equipments which may well be remote from the new load centres. The buried transformer, on the other hand, should be comparatively easy to site since it would need no plinth, railing or concealing structure but could be laid under a pavement or grass verge.

A transformer embodying these ideas has been developed by Ferranti, Ltd., Hollinwood, Lancs, with the co-operation of the South of Scotland Electricity Board, and it has been subjected to twelve months' field tests in the Clyde area. The transformer is an air-cooled 500kVA, 11,000/433V three-phase unit having class-C insulation and full instrumentation. It is contained in a strongly protected tank which is buried directly in the ground with only a small ventilating pillar showing above the surface, as can be seen from the accompanying illustration.

The ventilating pillar which separates the incoming cooling air from the outgoing air was designed on the lines of an overground distribution pillar. As it is offset to one side of the tank the core and coils can be installed or removed without difficulty; the pillar can be installed in a wall or hedge, the main tank being buried under the pavement, verge or garden. The pillar is designed to be fully weatherproof whilst allowing free ventilation. It is stated that the ventilating system is proof against blockage by stones or dirt, whether accidental or deliberate.

A damaged pillar can be safely replaced or repaired without disconnecting the transformer. Construction of this particular transformer was

Ventilating pillar of buried distribution transformer installed for field trials in the Clyde area

simplified by the omission of tappings; however, the manufacture of units with tapping links can also be undertaken, access being gained by a manhole cover as in standard Post Office practice.

Since the transformer was installed daily readings have been taken on site. These readings have included: kVA "printometer" readings; phase current measurement; outlet and inlet air duct temperatures; metal temperature at top of housing; air, soil and ambient temperatures.

The maximum rating at present in operation is 500kVA, but as operating experience is accumulated, this figure is likely to be increased to around 1500kVA. Following the successful field trails Ferranti, Ltd., has now received an order from the North of Scotland Hydro-Electric Board.

302 H.P. Diesel-Hydraulic Locomotive

We illustrate one of four 302 h.p. diesel-hydraulic locomotives being built by Andrew Barclay, Sons and Co., Ltd., Kilmarnock, for the Central Electricity Generating Board, for handling coal at the new power station at High Marnham. The weight of this locomotive in working order is 42 tons and the maximum tractive effort is 28,500 lb at 30 per cent adhesion and at 1½ m.p.h. It will run up to a maximum speed of about 14 m.p.h. with light loads and will start a load of 1600 tons on the level, assuming a starting resistance of 18 lb per ton, and will haul this load at a maximum speed of 2½ m.p.h. It will haul 1000 tons at 5 m.p.h. on the level. The makers point out that the speed range of this design of locomotive can be varied by altering the ratio of the final drive reduction gears so that a higher maximum speed can be provided if desired. This will, of course, necessitate a reduction in the maximum tractive effort at low speeds, but a locomotive which will run up to 20 m.p.h. would still have a maximum sustained tractive effort of 25,000 lb.

The three-stage Twin Disc torque converter fitted gives a torque multiplication of 5 or 6 : 1 and, as the necessary torque multiplication can be obtained in one unit, there is no necessity for change-over valves or complicated mechanisms to ensure engagement of gears at the appropriate speeds. The driver controls the train and the speed by use of the throttle and brake levers only. A plate-type friction clutch is provided between the engine and the torque converter in order to avoid running the converter while the locomotive is standing and also to facilitate reversing by removing the drag of the converter from the reversing gear teeth. This clutch is engaged with the engine idling and is not used to take up the load.

The locomotive has a Rolls-Royce eight-cylinder supercharged engine which develops 302 b.h.p. on a twelve-hour rating at 1750 r.p.m. The torque converter is connected to the engine crank case by an S.A.E. housing, making the engine and converter a single unit. The converter uses fuel oil as its working fluid and this oil is constantly changing as it circulates back to the tank through a bleed orifice. The necessary pressure is maintained in the torque converter by a gear pump mounted on the engine. As a precaution against over-heating of the converter fluid at high speed when running light, an output shaft governor is fitted to limit the maximum speed at which the locomotive can be driven.

A propeller shaft with Layrub flexible couplings is fitted between the torque converter and the reverse and final drive unit, which is of Wiseman manufacture. Westinghouse compressed air brake equipment is operated by a self-lapping driver's brake valve, compressed air being supplied by a 25 cubic feet air compressor driven by belt from an extension shaft at the front of the engine. All controls are mounted on a desk in the front of the cab and the throttle and brake controls are duplicated so that the locomotive can be driven from either side.

Industrial and Labour Notes

Forty Hour Week

At a meeting on Thursday of last week, the council of the Confederation of Shipbuilding and Engineering Unions discussed again the rejected claim for a shorter working week. It is reported that the council decided to refer the dispute over the claim to the Minister of Labour, the aim being to have the matter submitted to the Industrial Disputes Tribunal by December 10. That is the last date on which claims can be received for compulsory arbitration prior to the winding up of the tribunal.

The claim for a forty hour week in the shipbuilding and engineering industries was first lodged by the union confederation in the summer of last year. It was rejected by the employers' federations. Subsequently, the unions proposed that the shorter working week should be introduced in stages, a forty hour week being reached by the beginning of 1961. This alternative claim was refused by the employers' representatives at the end of August.

Trade Unions in 1957

A separate section of the annual report of the Chief Registrar of Friendly Societies, which has just been published, deals with the membership and finances of registered trade unions. This document records that during 1957 trade union membership increased from 8,549,000 to 8,593,000. The most marked increases in membership occurred in the unions concerned with mine and quarry workers, engineering and shipbuilding workers and paper and printing workers. In these three groups there were membership increases last year of 31,000, 47,000 and 9000 respectively. But in the " general labour organisations " membership declined by 27,000.

The income of the unions from their membership increased last year by £2,157,000 or 10·5 per cent ; this increase was achieved for the most part through rises in the rates of members' contributions. The working expenses of the unions increased last year by 7·4 per cent, compared with 7·2 per cent in 1956. About dispute benefits the report says that expenditure under this head has been increasing each year since 1952. The total expenditure on dispute benefit last year was £2,971,000 and was the highest since 1926, the year of the general strike. The largest single contributory cause of this increase in dispute benefit was the fifteen-day stoppage in the engineering and shipbuilding industries during March and April last year.

Iron and Steel

The improvement in steel production in September, following the effect of the holiday months, was not maintained during October. Output of ingots and castings averaged 363,500 tons a week which represents an annual production rate of 18,902,000 tons, compared with a rate of 22,766,000 tons in October last year. According to a Parliamentary reply, made last Monday, steel production is now running at about 78 per cent of capacity. Pig iron production was a little higher in October than in the two preceding months. It averaged 241,900 tons a week and was thus at an annual rate of 12,579,000 tons. A year ago, however, output was running at an annual rate of 14,844,000 tons.

The Iron and Steel Board reports that, in the third quarter of this year, total steel deliveries were 15 per cent lower than in the comparable period of 1957. The principal decline this year has been in all kinds of steel sections. In each quarter this year, deliveries of light sections have been below those of last year, while in the case of heavy sections deliveries were maintained during the first quarter of the year but fell off during the second and third quarters. At the same time, deliveries of strip mill sheet continue above last year's level. The Board says that the sharpest reductions this year in steel demand have occurred in the nationalised industries, notably coal mining and the railways, deliveries to which fell during the third quarter by 29 and 31 per cent respectively from last year's level. Shipbuilding and constructional engineering have also considerably reduced their purchases. In the general engineering group, electrical engineering is taking more steel but other branches less. The reduction in steel deliveries to the motor trade reflects the lower demand for commercial vehicles. The Board's report adds that producers' exports of steel have fallen proportionately more than their home trade. Export deliveries were 18 per cent lower in the third quarter of this year than in the corresponding period of 1957 while deliveries to the home trade were 14 per cent lower.

The Government's statement on the two new strip mill projects is reported on page 817.

Safety Training Centre

On Wednesday, a new safety training centre for foremen and others in the building and civil engineering industry was opened at the Government Training Centre, Enfield. The Ministry of Labour says that the establishment of this training centre marks a further development in the co-operation between the government and industry in a drive to cut down the numbers of accidents on building and civil engineering sites. Last year more than 16,000 accidents were reported in these industries, including 185 fatalities out of a total labour force of about 1,250,000.

The London Building and Engineering Contractors' Accident Prevention Group has been given the use of land and buildings at the Government Training Centre, Enfield, and member firms of the group have contributed money, materials and equipment to erect the shell of a two-storey building and to dig a trench which can be used to illustrate different methods of timbering excavations. Scaffolding is erected round the demonstration building to show the right and the wrong way of doing the job. It is expected that there will be about six courses a year, each accommodating thirty students ; these students will be building foremen and others whose everyday duties involve the maintenance of safety standards during building operations. Each course will last two days and will consist of lectures, demonstrations and practical exercises. The lecturers will be drawn from safety experts in the industry itself and from members of H.M. Factory Inspectorate. The courses will be similar in character to those which have been successfully run at the Birmingham Industrial Safety Training Centre over the past two years. Although the Ministry of Labour will co-operate as far as possible in the running of the courses the general control of them, and the responsibility for them, will rest entirely with the London Building and Engineering Contractors' Accident Prevention Group.

Overseas Trade

The Board of Trade has stated that, in the third quarter of this year, the volume index of imports rose by two points to 113 (1954=100). Imports were thus about 1 per cent higher than in the corresponding period of 1957, although, as a result of the improvement in the terms of trade, they cost roughly 5 per cent less than a year ago. With the notable exception of basic materials, the index for which fell to 90, the volume of imports in all classes was greater than in the third quarter of last year.

The volume index of exports for the third quarter rose by one point to 109 (1954=100). The Board of Trade says that, although this increase represents a slight recovery in the level of exports compared with the preceding quarter, when they were affected by the dock strike, the volume is still below that of the third quarter of 1957, as well as being 1½ per cent lower in terms of value. The rise in the volume of exports has been marked in food, beverages, tobacco and petroleum and petroleum products. Exports of manufactured goods as a whole, the index for which moved one point to 111, continue to lag and have not yet regained the volume attained in the third quarter of 1957. Analysis of the " manufactured goods " figures shows that exports of engineering products have tended to fall a little over the last six months. The volume index for this group in the third quarter was 118, compared with 121 for the whole of last year.

The export price index remained unchanged at 110 during the third quarter. Owing to a decline in the prices of basic materials, the import price index fell by one point to 98.

Export Credit Cover for Engineering Goods

The Export Credits Guarantee Department says that the arrangements have been simplified for cover on those engineering goods commonly sold on credit terms ranging from six months to three years maximum, whatever the unit value of those goods, which are covered by " extended terms " endorsements or memoranda attached to the normal short-term cover. The normal short-term cover continues to apply to raw materials and consumer goods, apart from motor-cars, for which terms in excess of six months have been and will continue to be covered on a " case by case " basis.

Hitherto the credit terms acceptable for insurance within the engineering goods field have been decided for each application for cover on an individual transaction. But the department has now informed such policy-holders that they can assume there will be no objection to credit terms up to two years maximum in respect of orders of £20,000 or more for either commercial credit users (such as distributors) or for end-user buyers ; and that there will be no objection to terms up to three years maximum for orders of £50,000 or more for end-user buyers. It is hoped that this will relieve exporters of uncertainty as to credit terms in much of the " extended terms " field, and thereby assist them in negotiation of business. Where the exporter seeks to give credit for longer periods than provided for above, it will still be necessary for him to make an individual case to the Exports Credits Guarantee Department, which in all cases retains underwriting discretion as to the other elements of a contract.

Centre National des Industries et des Techniques

No. I.

Inaugurated by the holding of the "Mécanélec 58" Exhibition recently, the Palais des Expositions du Centre National des Industries et des Techniques (C.N.I.T.) is scheduled for substantial completion next year. The groined vault roof of the hall, seen in the accompanying aerial view, is inscribed in an equilateral triangle with sides measuring 218m, and supported at only three points. This structure, unusual in form and in design, constructed in very short time, holds two world records: the longest known span for a shell structure, 206m at each façade and 238m at the groins, and the largest surface supported at a single point, 7000 square metres. The floor area totals nearly 100,000 square metres. Situated at the Place de la Défense, Puteaux, on the projected Concorde-Etoile axis, the C.N.I.T. forms the first building of an important development scheme.

ALTHOUGH the Grand Palais provides Paris with a centre for exhibitions of nearly 50,000 square metres of floor space, both its size and structure have become increasingly inadequate for the modern large exhibition which often involves the showing of heavy equipment. The engineering industries in particular have never had adequate exhibition facilities since the Galerie des Machines was demolished in 1909, and it is therefore not surprising that the initiative to build the new Palais des Expositions du Centre National des Industries et des Techniques, the C.N.I.T. for short, should have come from that quarter. It was the President of the Syndicat National des Constructeurs des Machines Outils, M. Emmanuel Pouvreau, who after the last war was instrumental in forming the Société Anonyme du Centre National des Industries et des Techniques in which participated the Federations of the Mechanical, Electrical, Chemical, Automobile, Iron and Steel, and Petroleum Industries, as well as the Banque de France, the Caisse des Dépôts et des Consignations, Gaz de France, Electricité de France, the S.N.C.F., the Régie Nationale des Usines Renault, and others.

This company acquired at the Place de la Défense at Puteaux (Seine), a triangular site of 40,000 square metres, bounded to the south by the Avenue Perronet. This short road forms the continuation beyond the Rond-Point de la Défense of the "Voie Triomphale," the great and as yet only partially completed avenue, already planned by Colbert to extend in a straight line from what now is the Place de la Concorde, to the Forest of St.-Germain. The other two boundaries are the Avenue de la Division Leclerc which also radiates from the Rond-Point, and the Rue Carpeaux, with the railway from St.-Lazare to St.-Germain behind it.

Since the days of 1871 when some of the heaviest fighting during the siege of Paris centred on the neighbouring fort of Mont Valérien, the area had formed a forgotten corner of the suburbs, housing a number of dwellings and small-scale factories. Thanks to M. Pouvreau's initiative, the construction is now nearing completion there of what will be the principal exhibition centre of France, and one of the most important of its kind in Europe. The shape of the site, and the need to utilise, in an elegant manner, a maximum of the available land, inspired the team of architects (MM. Camelot, de Mailly, and Zehrfuss) in co-operation with Monsieur N. Esquillan as Technical Director of the group of civil engineering firms Balency–Boussiron–Coignet, to design the unusual building shown in our title illustration.

A double reinforced concrete shell, in plan projection an equilateral triangle of 218m side, covering 21,000 square metres (the actual roof surface is 27,000 square metres), and rising at the centre to 51·1m above ground level, it is supported at the three corners, which together are built to carry a total of 14,200 tonnes dead load plus 1400 tonnes of snow and service load. Spreading of the supports is prevented by ties laid in the direction of the façades. The two ties which end at each corner are designed to carry a tension of 2×3750 tonnes = 7500 tonnes, equivalent to the weight of the Eiffel Tower.

Both with regard to span and roofed area per support (7000 square metres) it is the largest building in the world, spanning over twice the distance of the twin hangars at Marignane airport near Marseilles (1951)—by the same designer—each of which have a span of 101·5m (Fig. 1).*

It may be noted that the arch in the vertical plane of symmetry through any corner and the centre, would, if projected, span 238m. The span of the façades exceeds the width of the Place de la Concorde, and the rise is larger than the height of the Arc de Triomphe. The three façades totalling 10,000 square metres are completely glazed. Built into them are rectangular multi-storey structures, each comprising five floor levels, including ground floor. The ground and second level extend, without internal walls, throughout the building except for a hexagonal area of 800 square metres left open in the centre of the second level, which permits the vault to be seen from below. The first floor level forms a gallery extending internally around the whole circumference. Altogether there are 71,000 square metres of exhibition space with an additional 30,000 square metres of service area. The completed building will have a conference room, a cinema with 500 seats, a restaurant and self-service canteen for 1800, with 26,000 square metres of gardens and parking space for 3000 to 5000 vehicles outside. All floors have load capacities of 500 kg per square metre, except the centre second floor level which can carry a distributed load of 1 tonne per square metre plus certain point loads.

The public, of whom up to 60,000 are to be admitted simultaneously, obtain access by way of 124 doors, the main entrance being over a monumental staircase 75m wide and 6m high from the Avenue Perronet. A further seven doors are for goods traffic. All levels are interconnected by staircases and lifts. Public transport, by bus, railway (Métro and S.N.C.F.), and helicopter, is to be extended to the new Centre.

The total inclusive cost of the Centre will amount to an estimated 4000 million francs. Of this amount, the civil engineering works required 2400 million, or 24,000 francs per square metre of floor space. The whole amount was raised by industry without the aid of the Government, which, on the contrary, benefits through taxation to the extent of 500 million francs.

Before we go into the technical details of the C.N.I.T., note should be taken of the general impulse to development which this project has imparted. By decree of October 20, 1956, plans were approved for the rebuilding of the district on either side of the Défense–Etoile axis as far as both banks of the Seine at Neuilly, which is about 1km away (Fig. 2). This stretch (the Avenue du Général de Gaulle) is to be widened to 145m with double carriage-ways, a fly-over at

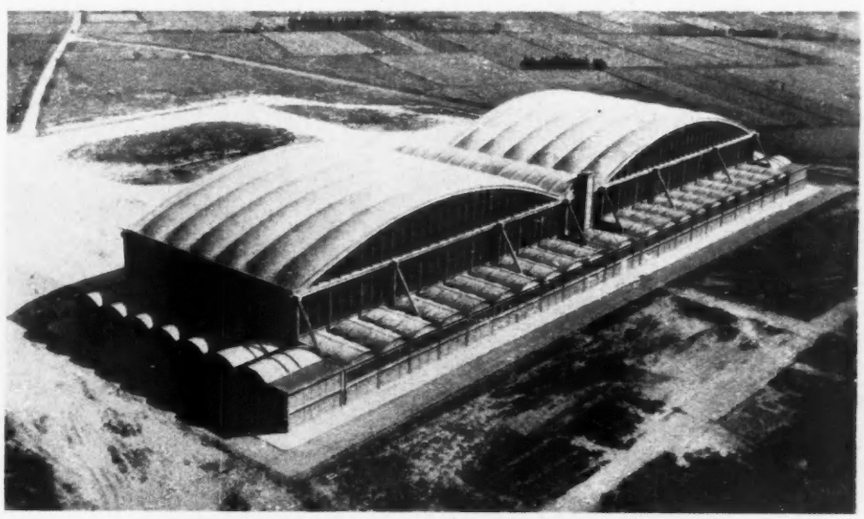


Fig. 1—The twin hangars at Marignane (Marseilles airport, 1951) have each a clear span of 101·5m with a rise of 12·1m. Built at ground level, the 60m long roofs were raised to their present height of 19m at the eaves by hydraulic jacks in daily stages of 1·06m. Each 6cm thick, single reinforced concrete shell comprises six corrugations of 9·8m span and 2·2m rise, stiffened by spandrels. The spreading force is taken up by high-tensile concrete-encased tie rods. The design is the evolutionary predecessor of the C.N.I.T.

*See *Supplement aux Annales de l'Institut Technique du Batiment et des Travaux Publics* (September 1952), Vol. 5, No. 5 (Series XX).

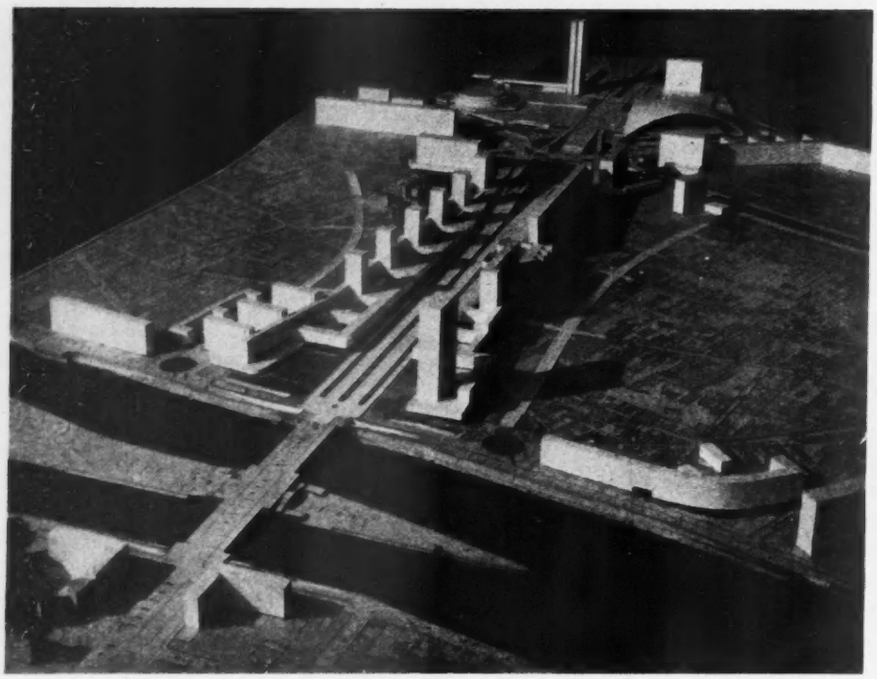


Fig. 2—Model showing proposed development of the Quartier de la Defense, Puteaux. The C.N.I.T. may be seen behind the Rond-Point de la Defense fly-over on the right. Facing it across the high-level road is the multi-storey Documentation and Study Centre. The scheme extends to the banks of the Seine at the Pont de Neuilly (foreground)

the Rond-Point de la Défense, and is to continue at a high level along the Avenue Perronet and over the railway line to St.-Germain, thereby circumventing the obstruction of low bridges on this line which at present impede exhibition traffic. Buildings to be erected under this long-term scheme include headquarters for many industrial federations and important enterprises ; facing the C.N.I.T., there is to be a Centre of Study and Documentation, which is to house all the agencies concerned with scientific and industrial documentation and information, as well as offices of the great international scientific societies.

History

The Société Anonyme du Centre National des Industries et des Techniques, as the owner, appointed the team of architects in 1951. Their preliminary design being approved, they approached a number of leading civil engineers for technical solutions which, in turn, were discussed with prospective main contractors. When, after three-and-a-half years of discussion, research and design work, the final solution had crystallised, it was possible at the same time to appoint contractors on the architects' recommendations. By this procedure, it is stated, it was possible to avoid the delays connected with the holding of a design competition and the subsequent calling for tenders.

To speed up matters further—for a term of only twenty-one months had been stipulated for completion—the contractor's design office (eleven engineers, eighteen draughtsmen) was housed in temporary quarters at the site. Since it would have been very difficult to find enough qualified labour (700 to 800 men) to carry out the work at such speed by standard methods, it became necessary to resort to a high degree of mechanisation and prefabrication. In this way, a labour force of 350 proved sufficient—300 at the site and fifty at a concrete batching and prefabrication plant at the Pont de Bezons, 4km away on the Seine. Over 350 million francs were spent on equipment and the total installed power of 2010kVA—nearly 6kVA per man—must be considered exceptionally high for this class of work.

The first earth movement began in July, 1955, and on May 8, 1956, the first concrete was poured. The order of construction was : foundations, columns, upper floors within area of roof, ground floor, centre roof section, upper floors outside roof area, second and third roof sections, façades ; some of the interior work has already been carried out on the lower levels, but work on the upper floors still remains to be done. Shuttering of the first section of the roof was struck on March 7, followed by the second section on June 27, and the last on September 2. Final completion of the building is scheduled for 1960.

Site

The site immediately adjoins the Rond-Point de la Défense at Puteaux (Seine) to the north-west. The ground slopes slightly to the north and consists of sandy clay with a seam of limestone rock between the depths of 12m and 13·5m.

Layout

In conformity with the triangular shape of the site, the three façades of the hall are mutually at 60 deg., facing the boundary roads as has been mentioned. Our illustration (Fig. 3) shows the outside from the Avenue de la Division Leclerc. The inside of the building (Fig. 4) is on three main levels : the ground floor at 49·5m sea level ; a gallery at 55·5m sea level running all along the circumference, and the main upper level at 61·5m sea level. At this level, the central floor area *A* rests on fifty-one columns arranged in a pattern of equilateral triangles of 18m side. The columns are 9·8m high and the hollow floor has an overall thickness of 2·2m ; constructed of prefabricated triangular units, it is a monolithic structure without any expansion joints, and of great strength, being designed for a distributed loading of 1 tonne per square metre of slab and, in addition, able to carry a lorry of 3·5 tonnes per wheel anywhere on the area supported by each column. The lower deck of this box structure, which is designed for a loading of 100 kg per square metre, is for service purposes.

The ground floor is of stabilised earth and is uninterrupted but for the columns which support the triangular floor above. A hexagonal well of 800 square metres in the centre of floor *A* allows one to see the underside of the roof from the ground.

These three levels (ground, first and second floor) extend outwards into rectangular multi-storey structures *B* built into the façades, as well as into the corners of the building (areas *C*). The structures *B* also have prefabricated floors, but use rectangular column spacings of 9m by 12m or 9m by 13·5m. In each façade there are two additional storeys above level *A*, at 66·5m and 71·5m sea level. Altogether, the five levels represent aggregate floor areas of 30,000, 18,000, 29,500, 10,000 and 12,500 square metres, respectively. The floors *C* being irregular, are cast *in situ*.

The façades of the building, totalling 10,000 square metres, are completely glazed. Their framework is self-supporting in the vertical direction and is arranged to allow the roof to rise or fall freely with changes in temperature.

Owing to the sloping nature of the site, lorries have direct access from the road to ground, first, and second floors. All floors are interconnected by staircases and lifts. The installation of escalators has for the time being been deferred.

For the exhibition of heavy machinery in particular, the adjoining hall, seen on the right in Fig. 3, has been provided. This hall extends

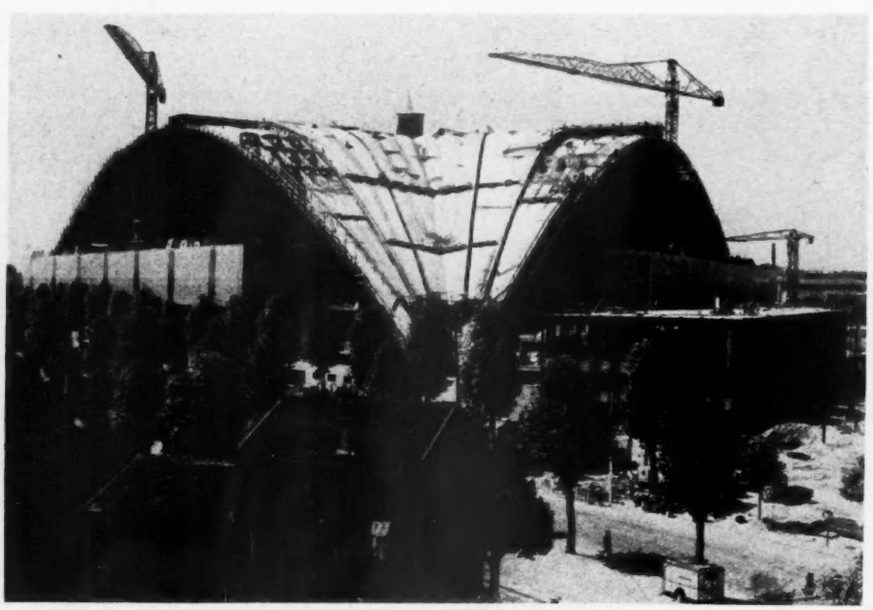


Fig. 3—The C.N.I.T. partially completed (summer, 1958). Note the assembly of the prefabricated elements on the outer sections of the roof, and the massive crown beams. The three sections of each nave are as yet separate, the two outer ones resting on hydraulic jacks with roller bearings at the crown taking side load components. The temporary building on top houses strain gauges and transmitters for controlling the cranes by radio

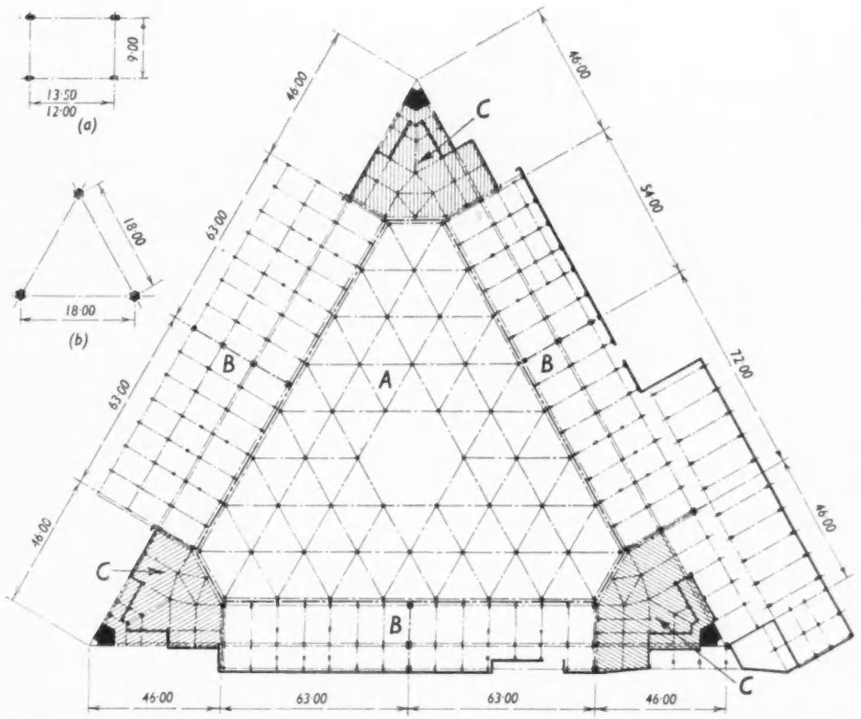


Fig. 4—Plan of C.N.I.T. showing floor areas (dimensions in metres). Ground floor, 30,000 square metres at 49·5m sea level, is surmounted by four upper floors, 18,000, 29,500, 10,000 and 12,500 square metres, respectively, at levels 55·5m, 61·5m, 66·5m and 71·5m sea level; the underside of the roof is 48m above ground at the highest point. Upper floor levels are distributed as follows: area *A* second level only, areas *B* levels 1 to 4, areas *C* levels 1 and 2 only. (*a*) shows the rectangular pattern of the columns supporting floor areas *B*; (*b*) the triangular pattern used in section *A*

to second-storey height and is equipped with a 20-ton travelling crane.

Foundations and Columns

The three vault supports at the corners of the roof take the form of 12m high blocks of concrete poured into excavations resting on the limestone at 13m depth. Each support was designed to carry a vertical load of 5200 tons (4740 tons deadweight, 460 tons snow and service), giving rise to a ground pressure of 8 kg per square centimetre. For counteracting the side thrust of the vault, the foundations are interconnected by ties passing along the line of the façades and buried to avoid the effects of temperature fluctuation. From each foundation block, two sets of cables pass in each direction, at a small angle to the horizontal, to a double anchor block, from where the tie is continued in the form of a single horizontal member to a similar anchor at the other side. These anchors extend downwards 15·25m through the limestone layer.

The columns supporting the central triangular floor at 18m pitch are 9·8m high and of downward-tapering, hexagonally fluted section of 0·8m base diameter. Designed for a total loading of nearly 500 tons, they are set on concrete foundations formed by the "Benoto" process. These consist of 6m deep blocks, 1·4m in diameter, with a mushroom footing 2·4m in diameter, transmitting a ground pressure of 11 kg per square centimetre.

The rectangular floors rest on columns having capacities between 100 and 500 tons and founded in a similar manner. The section near the top of the column fits a 1m by 0·5m rectangle and has rounded ends of 0·25m radius. Both kinds of column are depicted in Fig. 5.

Fig. 5—This view clearly shows the two principal floor designs, the two kinds of main columns, and the large twin staircases. The triangular central floor (left and centre) with columns 18m apart, can support 1 tonne per square metre plus live loads. The rectangular floors, like that on the right, can carry up to 500 kg per square metre

Floors and Staircases

Expansion joints divide the building into eleven sections, i.e. the central triangular floor, the three corners, six rectangular blocks (one on either side of the centre of each of the three façades), and the adjoining heavy machines exhibition hall.

In many respects outstanding is the design of the triangular main floor, area *A* in Fig. 4. As has been mentioned, it is a prestressed box design comprising an upper and a lower deck, the overall thickness being 2·2m. Each deck was built up from precast reinforced concrete units in the shape of equilateral triangles with 5·76m long sides. The top deck units, which weighed 4·5 tonnes apiece, were 8cm thick and had 0·6m deep ribs along their circumference, while the bottom deck was constructed of 6cm thick units weighing only 3 tonnes and having a smaller, 0·33m deep flange. Each unit was cast with a central hole 0·3m in diameter, which is normally kept plugged but is available to conduct the internally laid services to the floor above, or, in the case of lighting, to the ceiling below.

Our illustrations Figs. 5 and 6 show this arrangement. The internal clearance is 1·81m, sufficient for a man to walk upright.

In erecting the floor, use was made of the previously constructed columns and of tubular steel trestles to support the lower deck elements, of which there were nine in each area subtended by three neighbouring columns. The upper slabs were then laid on top of temporary trestles resting on the lower deck. The 0·24m-wide cavities left between adjacent ribs were filled with concrete, thus joining the components into an unbroken floor area. Along the lines of the columns, the fillings were continued vertically to join with the upper ribs to form internal webs. These are continuous except for a rectangular opening 5·4m long and 1m high at the centre of each 18m span. Near the top and bottom of each web were inserted a pair of prestressing cables, which are up to 144m long and were tensioned in stages to about 100 tonnes according to the "Boussiron B.B.R." process. In order to allow the cables to pass cross-over points in a straight line—two by six cables cross at each column—they had to be run at different levels, but in all cases the tensions were adjusted so that the resultant force should be in the neutral plane of the floor section. At the centre of each 18m triangle the upper and lower slabs are joined by a prefabricated concrete post. A total of 1294 slabs and seventy-two posts were used.

Investigation of this floor design showed that under point loading there takes place a "migration" of the prestressing into the slab due to the creation of "virtual beams" which considerably strengthens the slab.

The average concrete consumption, for both decks together, was 0·35 cubic metre per square metre, the amount of "Caron" reinforcement steel (24 kg per square millimetre) was 32 kg per square metre, and that of mild steel reinforcements, 8 kg per square metre. The prestressing cables contributed another 6·5 kg per square metre.

Rectangular and Corner Floors

The areas marked *B* in Fig. 4 were carried out as prefabricated floors based on the rectangular module 9m by 1·5m. Two column spacings were used, viz. 9m by 12m, and 9m by 13·5m. The columns are joined by beams in the direction of the larger distance, standard precast slabs being laid crosswise to bridge the shorter span.

As it was impossible to transport, and place by crane, complete precast main beams of the sizes required, recourse was had to a method which employed precast components as moulds which were converted into the complete beam, and at the same time joined to the rest of the structure, by filling them with concrete *in situ*. This procedure is similar to that described above

in connection with the triangular floor, except that here no extra shuttering was required.

The rectangular floor slabs, as cast, measured 8·68m by 1·47m by 0·06m thick with 0·5m deep ribs all round the edges tapering from 12cm down to 9cm. The long edges were rebated at the top so that the slabs could be joined by grouting the recesses thus formed.

The floors were erected by spanning the columns with precast U-channels, placed hollow side upwards. These channels measured 0·5m by 0·5m in section, with a 15cm thick web and 9cm thick flanges, and contained all the reinforcement steel of the final beam. By themselves they were, however, not load-supporting, and therefore had to be temporarily underpinned. The ends of the floor slabs were rested on the upturned flanges of the channels, leaving a trough 0·32m wide and 0·85m deep which was filled with *in situ* concrete. The ends of these troughs were formed by the narrow sides of the columns.

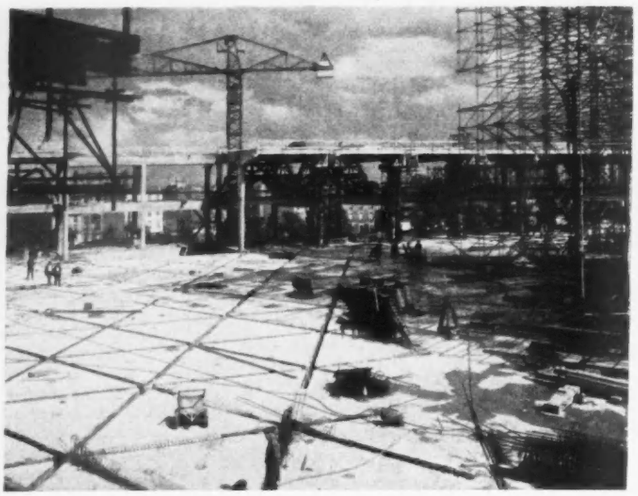


Fig. 6—Another view of the triangular floor during construction, while at the back some of the upper rectangular floors are being placed. On the right is part of the roof scaffold

The rectangular floors, totalling 53,000 square metres, are designed for a loading of 500 kg per square metre. The U-channels, of which 400 were required, each weighed 4 to 6 tonnes depending on length. There were 4000 slabs, each weighing 4·2 tonnes. This represents a total concrete consumption for the rectangular flooring of 0·2 cubic metre per square metre, involving a steel consumption of 18 kg of " Caron " steel per square metre.

The corner floors, which are marked *C* in Fig. 4, total 3000 square metres. They are on two levels (first and second floor). Owing to the irregular layout they had to be cast completely *in situ* in the traditional manner.

Staircases

The principal connection between floors is by nine sets of twin staircases, two of which may be seen in Fig. 5. It will be noted that they consist of flights of stairs placed side by side and rising in opposite directions, with common landings joining the two staircases at half-storey level. Each flight has a width of 3·1m (or 3·2m) and a thickness of 0·33m, and spans the considerable distance of 18m without intermediate support. Special measures were required to support the horizontal tensions and compressions of about 50 tonnes set up in the supporting floors.

(To be concluded)

Lake of Constance Aqueduct

AFTER a period of construction of four years, the Lake of Constance long-distance aqueduct has been completed as far as Stuttgart. This new water supply, which has a capacity of 2160 litres per second, will be extended northwards next year to Ludwigsburg and Bietigheim. Its construction was necessitated by the enormous increase in consumption which began in the 1920s and has continued ever since, except for a temporary drop during the latter part of World War II. As elsewhere, this increase is not only due to a larger population, but the amount required per head per day has drastically gone up, due to industrial expansion. According to the current ten-year plan of the Land Baden-Württemberg, the *per capita* water consumption will reach 250 to 350 litres per head per day during the next four years. This may appear a moderate figure. It is expected to prove to be fairly accurate, on the strength of the accuracy of previous forecasts which were within ±10 per cent.

Characteristic for Baden-Württemberg is the wide diffusion of industry which, in the absence of basic industries owing to the lack of coal and ores, from an early date tended to develop as typical light industry (textiles, precision engineering, tools). Such industries are not tied to any particular location, but, nevertheless, tended to be attracted to existing centres of settlement which are concentrated for the most part in the valleys of the Rhine and Neckar. Much of the Neckar area lies in the lee of the Black Forest mountains, and as a result has a rainfall of only up to 1000mm per annum, a large part of which includes Stuttgart, having only up to 700mm per annum, whereas the Black Forest receives 1000–2000mm and more. A review of the development over the last eighty years has shown that Middle Württemberg, the foothills of the Swabian Alb, the Zollernalb, Upper Neckar, Upper Danube, and part of the Black Forest around Hegau, may be expected by 1980 to require a total water supply of 3·0 to 4·5 cubic metres per second.

Five projects for improving the position have been suggested since the early years of the century. A twin aqueduct from Lake Constance to Stuttgart, one branch via Tübingen and the other through Ulm, was proposed in 1909, a scheme for obtaining water from the Danube was put forward in 1912, and a scheme for taking water from both the Rhine below Karlsruhe and from Lake Constance, was mooted as recently as 1948. Further consideration, however, showed that the Rhine would only yield about 1000 litres per second if a serious lowering of the water table in dry years was to be avoided ; the upper Danube also carries insufficient water, and the same applies to its contributory, the Iller, as well as to another source of river water, the Eyach in the Black Forest (500 litres per second). By contrast, the quantities of water in the Lake of Constance appear well-nigh inexhaustible. Measuring 538 square kilometres in area, it holds a volume of 48,000 million cubic metres, equivalent to seven years' consumption in the Federal Republic, both domestic and industrial. The River Rhine which flows through the lake, has a flow of between 100 and 1080 cubic metres per second (average about 365 cubic metres per second), two-thirds of the annual total occurring in the summer. The initial rate of withdrawal by means of the aqueduct amounts to 30,000,000 cubic metres per year, equal to 0·3 per cent of the outflow from the lake into the Rhine, or 0·1 per cent of the annual flow at Basle. Very soon, however, the full present capacity of about 70,000,000 cubic metres per annum will be utilised.

Although a number of communities, both Swiss and German, have used lake water from several different points along the lake for many years, the part of most interest for a major supply scheme was found to be the north-western arm, known as the Lake of Uberlingen, which extends over 61 square kilometres and holds some 5000 million cubic metres. Bounded on one side by a rocky shore, on the other by forests,

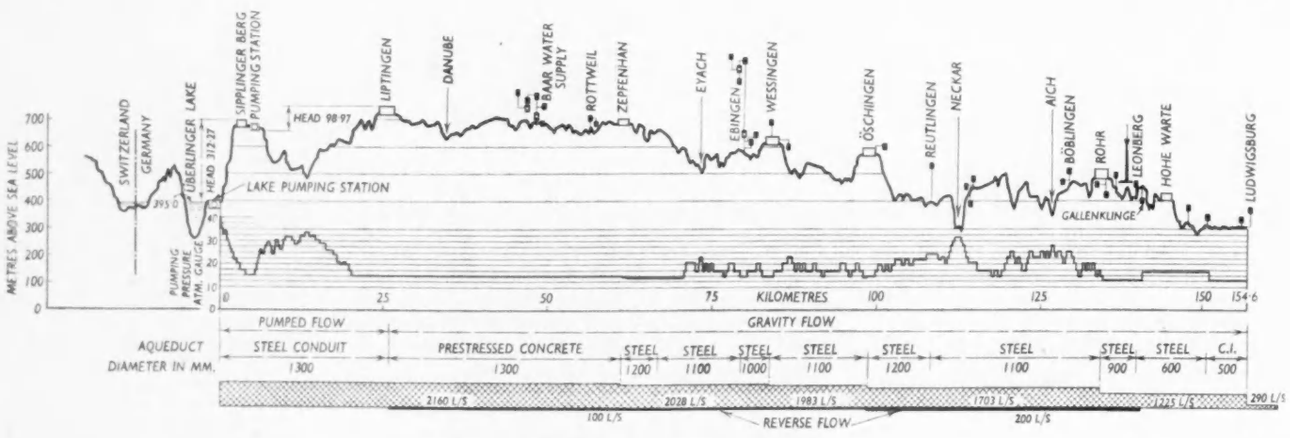


Fig. 1—Elevation of Lake Constance aqueduct

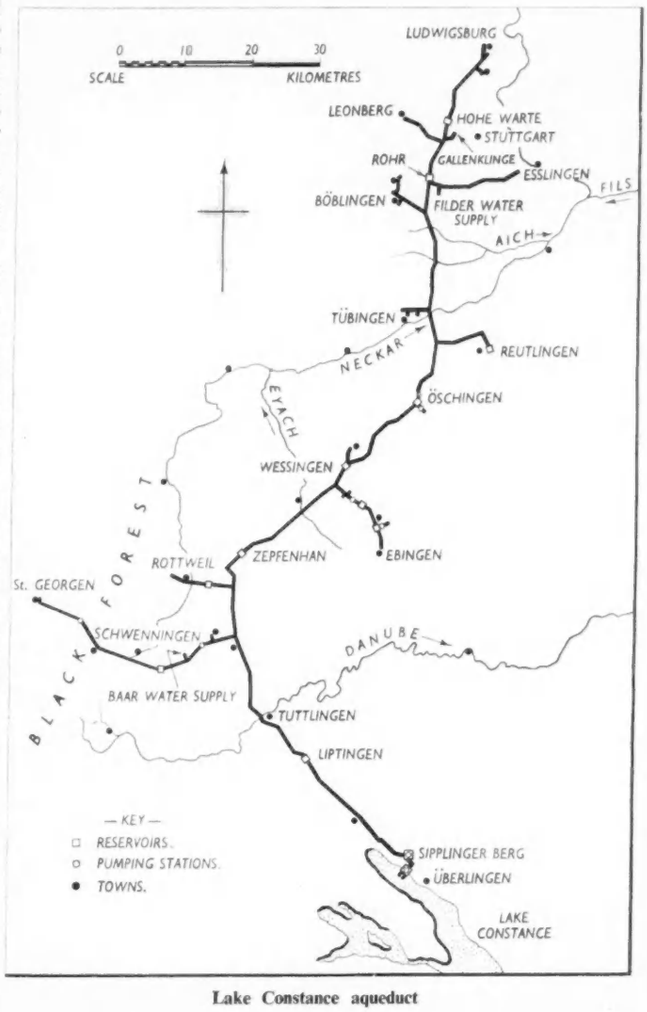
with few human habitations, the waters of the up to 147m deep Uberlingen lake are of high quality. Researches carried out in 1953 at an experimental filter plant 1·8km east of the village of Sipplingen showed that at a depth of 50m to 60m the temperature is 4 deg. to 6 deg. Cent. ; hardness is 7–10 deg., bacterial counts vary from 0–5 during the summer to less than 100 per litre during the winter (when vertical mixing through convection takes place). The pH value is around 7·5, the oxygen consumption 0·5 to 1·3 milligrammes per litre, the consumption of KMnO4 is 8·4 milligrammes per litre. The Uberlingen lake is not affected by the current of the River Rhine.

On the basis of those tests, the take-off and initial pumping station of the aqueduct was erected at Sipplingen. Water is obtained from a depth of 60m through two 450m long suction pipes of 1300mm bore diameter. Four pumps are installed, two in each of the two subterranean machine halls which are 14m below ground level. These pumps deliver 750 litres per second against a head of 305m to 315m. There are two tanks fitted in front of the pump inlets which serve as surge chambers. Room is available for installing further pump units, so as to bring the output of the aqueduct up to 3000 litres per second.

Current is supplied by two separate 110kV overhead lines, from the Schluchsee power station and the Nordostschweizerisches Kraftwerk, to the 110kV switching station on the Höhe Hödingen. Of the total installed power of 15MW, two-thirds is used in the lake pumping station and the remainder in the filtration and pumping plant at Sipplinger Berg. For the sake of preserving the landscape, the 110kV supply for both stations is taken from the switching station not by an overhead line but by two 110kV pressure gas cables to the substation where it is stepped down to 6kV by two 16MVA transformers. This installation is controlled from the Badenwerk switching station and the lake pumping station. An accumulator battery and diesel set are used for the control installation and as an emergency supply.

From Lake Constance to Bietigheim the main pipeline has a length of 154km and is subdivided into two pump sections and one gravity flow section. The first pumped section is from the lake station 394m above sea level (1m below the level of the lake) to the 3·4km distant Sipplinger Berg station at 695m above sea level. This part of the pipe has a diameter of 1300mm and, over two lengths of 275m and 100m, respectively, is laid in underground tunnels so as not to disturb the amenities of the district. From the Sipplinger mountain to the Liptingen reservoir runs the 22km long second pressure section, also 1300mm in diameter and constructed of steel. Working pressure in these two sections varies between 15 and 40 atmospheres. This reservoir, with a bottom level of 748m above sea level, is in the watershed between the Lake of Constance and the Danube.

From Liptingen to the Zepfenhan (Eichenberg) reservoir, a distance of 36km, the line is constructed in prestressed concrete with the same internal diameter as before. The remaining distance to Ludwigsburg is, or will be, constructed in welded steel conduit of 600mm to 1300mm nominal diameter, with about 5km of cast pipe of 500mm diameter in the last section. Branch connections total 120km and are carried in steel or cast iron with diameters ranging from 100mm to 800mm.



Lake Constance aqueduct

The filtration plant on the Sipplinger Berg comprises four sets of three rapid action open filters, each 100 square metres in area, filled to 1m depth with sand of 0·5mm to 0·8mm grain size, the flow resistance corresponding to 3·5m H_2O. Filtration is carried out under natural gradient, the water flowing from a 30,000 cubic metres raw water reservoir (which can be increased to 120,000 cubic metres) through the filters to a 20,000 cubic metres clean water reservoir. From there the water is pumped to Liptingen by four pumps against a head of about 100m.

There are eight reservoirs, including the two at Sipplinger Berg, i.e. at Liptingen (volume 20,000 cubic metres, water depth 5·5m, bottom of reservoir 748m above sea level), Zepfenhan (10,000 cubic metres, 5m, 701m above sea level), Wessingen (Bismarckhöhe) (15,000 cubic metres, 7m, 633m above sea level), Oschingen (Schlossbuckel) (15,000 cubic metres, 7m, 591m above sea level), Rohr (25,000 cubic metres, 7m, 519m above sea level), and Hohe Warte, near Stuttgart (10,000 cubic metres, 6m, 426m above sea level). Other reservoirs, totalling 12,000 cubic metres, are installed in the branch aqueducts to Schwenningen, Ebingen and Reutlingen, bringing the total reservoir capacity to 107,000 cubic metres.

All the reservoirs are constructed underground on the twin chamber system, with reinforced concrete walls and covered roof.

Control of the water quality and observation of conditions in the lake will be carried out by the former experimental filtration station, which has three rapid-action open filters of 12·6 square metres and laboratories for bacteriology, biology and chemistry.

The system will be connected to the Filder aqueduct at Esslingen, and will be operated in conjunction with it.

Of the total estimated cost of the scheme of DM.215 million, DM.190 million have been spent so far: 80 per cent of the cost was for the pipeline and only 1·3 per cent for sites and compensation for damage to crops. Increases in wages and the cost of materials during the whole five-year period of construction will probably be balanced by reductions in the rate of interest and savings on interest payments. Of the total amount, the Land of Baden-Württemberg contributed DM45,000,000 as an outright grant, as well as a loan of DM.26,000,000, the local authorities contributed DM.43,000,000 and the remainder is to come from other sources. If a local authority has a consumption of only 50 per cent of its full planned demand, it will be charged at the rate of 62·4Pf. per cubic metre (58Pf. next year, when all authorities will have been connected), while with a 100 per cent planned demand the rate reduces to 35·84Pf. per cubic metre. The pumping costs at present run at up to 9·3Pf. per cubic metre and are almost entirely composed of electricity charges amounting to 1·5kWh per cubic metre.

O.E.E.C. Plans More Scientists

Action by the O.E.E.C. countries during the current year to increase the supply of scientists and engineers was reviewed by the Council of the O.E.E.C. This includes steps to improve the teaching of science and mathematics, a programme for the exchange of senior scientists and the support of training institutions in specialised scientific fields. The policy for next year will be considered by the Council on December 15. The U.S. Government has offered to increase its contribution to the programme from 500,000 dollars to up to 750,000 dollars, to be matched by an equal contribution from the O.E.E.C. countries. The O.E.E.C. will, in the next year, improve the data on the demand and supply of scientists and engineers ; improve the secondary school teaching of science and mathematics ; help to exchange senior scientists between training or research institutions in member countries (a programme of senior visiting fellowships financed from a general fund to be put into action immediately). The O.E.E.C. will, moreover, support individual training institutions in important highly specialised fields and seek effective ways for scientific and technical training in industry. Training and utilisation of scientific and technical personnel in the participating countries are to be reviewed annually, for which purpose the first meeting will be held in Paris on December 3 and 4, when the situation in Great Britain, Denmark and Norway will be examined. Further meetings will take place throughout the year.

International Atomic Energy Agency Mission to Egypt

Following a request from the United Arab Republic to provide an expert on the production of uranium from phosphate ores and another on the production of heavy water, a three-man exploratory mission from the International Atomic Energy Agency has left Vienna for Cairo. Egypt is rich in phosphates and is interested to know whether the extraction of uranium from these ores might prove a feasible and economic operation. An ammonium nitrate fertiliser factory is now being constructed at Aswan and a study is to be made of the possibilities and the economic interest of producing heavy water by the electrolytic method as a by-product. The report of the experts will serve as a basis for deciding on what steps might be taken in meeting future United Arab Republic requests for technical assistance in these fields. The two expert members of the mission have been made available to the Agency by the U.S.S.R. and U.S.A. governments under a programme of "free consultants," in which a number of I.A.E.A. member governments participate.

Automatic Sorting Machine for Letter Mail

BY OUR AMERICAN EDITOR

An interesting prototype machine for the automatic, high-speed sorting of letter mail has been developed by the Rabinow Engineering Company, of Washington, D.C., under a contract arranged and supervised by the National Bureau of Standards for the U.S. Post Office Department. The machine is designed to sort at the rate of 36,000 letters per hour into as many categories as may be needed. Sorting can be directed either by a built-in electronic control, by human operators, or by a combination of both. The system is of modular design and thus adaptable to the varying needs of different post offices, with regard to both sorting complexity and space requirements. The machine has proved successful in laboratory tests, and the U.S. Post Office Department has recently let a contract for the construction of a 1000-pocket production machine to be used in a post office.

FOR some time the U.S. Post Office Department has been seeking mechanised sorting methods to assist its personnel in keeping up with the continuing rapid growth of letter mail. Because of its specialised experience with data processing machines and electronic equipment, the National Bureau of Standards has been aiding the Post Office on various mechanisation problems. The Bureau has been developing methods and machines to speed the handling of mail, with much of the equipment development and nearly all construction work having been placed in the hands of private industry. Two basic problems are involved in mechanised letter sorting. One is concerned with the information content of the address and with the mechanics of the control that must be provided by some computer-like device for directing the mail sorting. The other problem is concerned with the physical handling of the mail. To-day's envelopes and their contents are obviously not designed for mass handling by machine. This fact complicated the design of the present machine. If eventually standardised envelopes and addresses could be made acceptable for wide-scale use the task of the machines would be much easier and the cost be reduced.

Work on these problems at the Bureau has proceeded along several lines. Data have been and are being collected in representative cities to form an engineering basis for the system and machine design. These data include such items as the general nature of the mail, i.e. the size and shapes of envelopes, the proportions of handwritten and typewritten mail, and the range of colour of envelopes ; the number of letters handled each day and their distribution by times of day ; and the nature of distribution of local mail and outgoing mail. Studies are under way on methods of converting the written or printed address into a code printed on the envelope either with visible or invisible inks, or with magnetic materials. The development of special phosphorescent inks for this purpose is also in process. The sorting machine (Figs. 1 and 3) developed by the Rabinow Engineering Company consists essentially of a large number of pockets on an endless conveyor and electro-mechanical equipment that controls the dropping of a letter from a pocket into a specific fixed receptacle. Accompanying each pocket on the conveyor is a steel rod carrying twelve nylon wheels. Each wheel can be shifted laterally on the rod into one of two positions. Thus, there are 2^{12} or 4096 combinations of wheel positions. As the conveyor moves, each set of twelve wheels rolls over tracks (Fig. 5) designed so that, when the correct destination is reached, all the wheels drop into depressions and the letter is released.

The mechanical sorting and coding of letter mail begins at the code printer. Here letters from a stack of " faced " mail, moved by a conveyor belt, are picked off one at a time and mechanically placed in a reading-and-coding position in front of an operator (Fig. 4). He reads the addresses, abbreviates their important parts, and types these abbreviations on the back of the envelope by means of a special printer. The print coding is in a binary form, requiring six bits for each alpha-numeric character. For outgoing mail, the coding operator may merely abbreviate the city and the state. The choice depends on whether all the coding is to be done at the initial location or part of the coding at the final destination, and on whether the city to which the letter is addressed is or is not equipped with automatic machinery. In sorting for local distribution, the city need not be mentioned, and only the street number and street name will be coded. In any case, not more than sixty-four bits would be required for the entire abbreviated address. The operator then chooses, by push-button operation, one of four possible destinations—local, outgoing, airmail, or miscellaneous—and sends the coded letter through its first sort. The mechanism actuated by the push button opens a trap door and sets a directing vane so that the coded letter drops into the proper presort when it is released from the code printer. It is expected that only a few seconds will be required to code an average letter. This operation may ultimately become the only human one in the entire sorting process. The reading head of the code reader is physically placed in the reader-feeder-inserter mechanism immediately preceding the point where the letter is dropped into the conveyor. The sorting system is organised so that when adequate automatic reading machines become available they can be incorporated into the sorter with a minimum of alteration.

An electronic directory, sometimes called a memory or a translator, receives the coded, abbreviated address from the code reader, " looks up " the sorting destination for each address and controls the delivery of the letter to the receptacle belonging to that destination. The electronic directory output drives the code wheel setter, which sets each group of code wheels on the conveyor carts to the appropriate

Fig. 1—Removal of sorted letters from the destination receptacles at the bottom of the sorting machine

Fig. 2—Electro-mechanical-optical directory for converting 64-bit code address information into 12-bit code receptacle selection

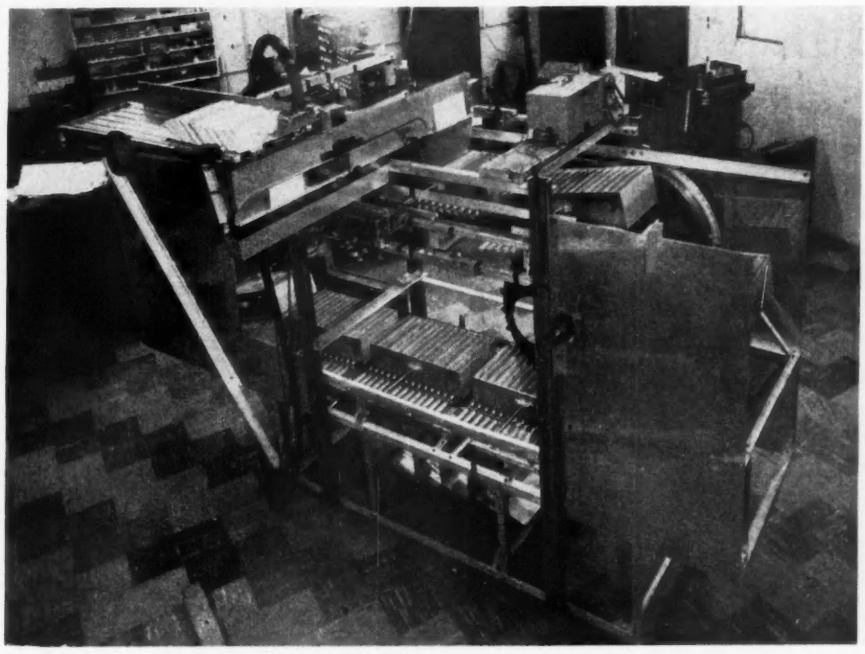


Fig. 3—Prototype machine developed for the U.S. Post Office Department for the automatic sorting of letter mail

coded arrangement to drop each letter in its final sort receptacle. The entire sequence involved in looking up the destination and setting the wheels is accomplished in approximately one-tenth of a second. The electronic directory is an electro-mechanical-optical device specially designed to meet the requirements of the sorting machine. It converts, according to a pre-arranged schedule, the information in the 64-bit code of the abbreviated address on the envelope into a 12-bit code corresponding to the receptacle where the letter is to be dropped by the conveyor. The directory consists of a stack of sixty-four thin plates of stainless steel, each approximately 1ft square. Each plate has etched into it 40,000 small round holes, about one-thirtieth of an inch in diameter, spaced on $\frac{1}{16}$in centres. The plates are suspended so that they can be moved by an electromagnet from left to right by $\frac{1}{16}$in. The plates are initially covered with an opaque black ink that fills the holes completely. Some of the holes are punched out to provide the directory with its address conversion data. Each plate corresponds to a dot position of the binary address code. If the code contains the full sixty-four dot positions, and if, by convention, each plate moves to the right if the dot is present and remains stationary if the dot is absent, then each address will cause the plates to move into a unique set of positions.

Behind this set of plates are situated twelve photo-electric cells, each of which "sees" an area of roughly 3in by 4in of the plate stack. These areas do not overlap. In front of the plates is a source of light that illuminates the whole area of the plate stack. Removing the ink from certain of the holes in each plate to permit the light to reach any desired combination of photo-cells creates a function table which converts a 64-bit input into a 12-bit output (Fig. 2). This 12-bit output is the control for setting the twelve wheels that accompany each letter in the conveyor. Etching holes in the plates and then filling them with ink ensures an accurate position for each final hole so that any set of sixty-four corresponding holes in the stack will line up. The directory contains approximately 1,500,000 bits and no trouble with mechanical alignment of the holes been experienced so far. The plates can be moved easily in one-tenth of a second, thus keeping up with the rate of the sorting conveyor. This kind of optical directory can also be used as any general-purpose function table. A much larger number of holes per plate, larger plates, or several sets of plates in parallel could be used and many variations of the basic scheme are possible. The memory in its present form could handle a city of 100,000 to 200,000.

Fig. 4—Code printing unit for applying a binary code to the back of each individual letter

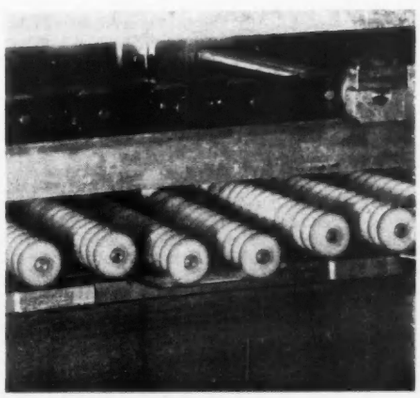


Fig. 5—Close-up view of endless sorting conveyors with twelve code wheels per pocket travelling over contoured tracks

Each letter is inserted by the reader-feeder-inserter into a separate pocket on the conveyor. At the same time the code wheels for each pocket are set according to the output of the directory so that its letter will be deposited into the proper final sort receptacle. A code wheel resetter returns all code wheels to their "zero" position following the dropping of the letter into the receptacle. The empty pockets are then reloaded and their corresponding code wheels are set for another sort.

In a less complex version of the machine, letter sorting is controlled by human operators instead of the equipment which reads the dot code printed on the envelope. The operators sit beside the conveyor belt, and letters are delivered to them automatically. Each operator reads the address, decides which receptacle of the conveyor the letter is to go into and depresses a combination of keys. This operation sets the position of the wheels accompanying the pocket into which the letter will be dropped. At no time does the operator touch the letter. Such a machine can sort mail at rates as fast as one per second for each operator. It is expected that the initial version of the machine will sort letters at the approximate rate of ten per second, thus requiring ten to twelve operators.

The sorting conveyor can be built in small modules so that machines of various sizes can be constructed to suit the particular size of the post office or of the sorting system used. The conveyor can be assembled in many layers so as to utilise best the available space in a particular building. Because the letters are carried vertically and their motion is perpendicular to their faces, the overall speed of the conveyor can be kept low. Gravity drops are employed both for placing the letters into the conveyor and for removing them from the conveyor into their final receptacles. Considerable effort was spent to design the machinery in such a way that the "facing" of the letters will be preserved, i.e. that the addresses on the envelopes will still face in the same direction after being sorted. Thus, refacing will not be necessary for any subsequent processing.

Special provisions are being made to enable the conveyors to be stacked in various arrays so that the letters can transfer from one conveyor to another for multiple sorting purposes. The Bureau is making studies to find systems of sorting mail which will be economical both in the cost of machinery and in the effective employment of operating personnel. It is possible to sort letters by short conveyors and use several successive sorts, or to use long conveyors and fewer sorts, or combinations of short and long conveyors, so that some mail is sorted only once while other mail is sorted more often, depending on the volume and statistical distribution. Many of the factors involved in system design are difficult to evaluate, such as the question of repeated handling of envelopes not designed for machine use as compared with the cost of large machinery where the letter need be handled only once. Actual experience with these machines in a post office should help to settle such problems in the course of the next few years.

Fast Construction of Airfield Runway

THE construction of a runway and its associated taxiway at Beale Air Force base in California has been described in our contemporary *Engineering News Record*. The controlling factor in the progress of the work was stated to be the concreting, of which there was 500,000 cubic yards. Construction was concentrated in two summer seasons of two or three months each, and proceeded at an average daily rate of 5500 cubic yards, it was stated. Five paving machines were in use simultaneously, with shifts up to fourteen hours. They were served by up to twenty-four trucks, each carrying five $1\frac{1}{2}$ cubic yard batches. The main runway is 12,000ft by 300ft, with 17,000ft of 75ft taxiway and an apron about 2000ft by 700ft in area. The concrete thicknesses varied between 20in and 25in.

Personal and Business

Appointments

MR. J. C. DRIVER has been appointed applications engineer of West Instrument, Ltd.

MR. E. D. DAWSON has been appointed a director of the Selson Machine Tool Company, Ltd.

MR. DONALD C. ALTMAN has been appointed assistant managing director of Allis-Chalmers Great Britain, Ltd.

MR. L. A. MILLS has been appointed commercial manager of the Osram Lamp Division of The General Electric Company, Ltd.

SIR JOHN WRIGHTSON, Bt., and Major-General C. A. L. Dunphie have been elected to the council of the Industrial Welfare Society.

THE COUNCIL OF IRONFOUNDRY ASSOCIATIONS has appointed Mr. F. C. Hayes to be training officer in succession to the late Mr. John Collett.

MR. LUDWIG EDWARD FRAENKEL has become a reader in aerodynamics, Imperial College of Science and Technology, University of London.

THE AMBER CHEMICAL COMPANY, Ltd., announces that Mr. J. Firminger has been appointed technical manager. Mr. H. N. Wigan has resigned from the board of directors.

MR. H. N. ADAMS has been appointed to succeed the late Mr. W. N. McCann as branch manager of Silvertown Rubber Company, Ltd., at Broughton Bridge, Blackfriars Road, Manchester, 3.

MR. E. L. FULLER has relinquished his post of managing director of Woodfield Rochester, Ltd., and has assumed the duties of executive vice-chairman. Mr. R. Keir Watson has been appointed managing director.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., has announced that Mr. S. C. Heward, A.M.I.E.E., has been appointed manager, associated companies division, and Mr. G. T. Kelsey, manager of the company's London office.

THE DE HAVILLAND ENGINE COMPANY, Ltd., states that Mr. W. F. Shaylor, commercial manager, and Professor A. D. Baxter, M.I.Mech.E., chief executive of the rocket division and the nuclear power group have been appointed directors with effect from December 1.

BIRFIELD, Ltd., announces that Mr. Eric Walker has been appointed managing director of the Phosphor Bronze Company, Ltd. He will be assisted by Mr. Philip A. Broadbent as works manager, Mr. Jack Kitchen as sales manager, and Mr. Gordon Swinyard as chief metallurgist.

THE LONDON CHAMBER OF COMMERCE announces hat Mr. Allen L. Stock, managing director of the Morgan Crucible Company, Ltd., has been elected chairman in succession to Sir Harold Gillett. Mr. R. L. Wills has been elected deputy-chairman, and Mr. F. H. Tate, treasurer.

TECALEMIT, Ltd., announces the following appointments: Mr. B. E. Richmond has relinquished his position as general factory manager to enable him to concentrate his activities as managing director of Foamite, Ltd. Mr. J. E. Drinkwater has been appointed to succeed Mr. Richmond as general factory manager, and Mr. H. E. Jackson has been appointed chief engineer.

THE DE HAVILLAND AIRCRAFT COMPANY, Ltd., announces that with effect from December 1, Mr. R. G. McCoy, A.F.R.Ae.S., has been appointed general manager, and Mr. D. R. Newman, A.F.R.Ae.S., chief aerodynamicist. Mr. C. T. Wilkins, chief designer, and Mr. John Cunningham, chief test pilot, have been appointed directors. Mr. R. E. Bishop has been appointed deputy managing director, and Mr. R. M. Clarkson, research director. Mr. Harry Povey is to retire from the board of directors on November 30.

THE SHIPBUILDING EMPLOYERS' ASSOCIATION announces that Mr. R. W. Johnson, chairman and managing director of Cammell Laird and Co. (Shipbuilders and Engineers), Ltd., has been elected president, in succession to Mr. G. C. Parker. Mr. G. H. R. Towers was appointed senior vice-president, the other vice-presidents appointed being Mr. J. Rannie and Mr. R. C. Thompson. Mr. L. Redshaw, director and shipbuilding general manager of Vickers-Armstrongs (Shipbuilders), Ltd., was elected chairman of the Conference and Works Board and Mr. A. H. Weeks was appointed vice-chairman.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., has announced the following appointments in the A.E.I. turbine-generator division: Mr. J. Richmond has been appointed divisional executive (Rugby) and sales manager (Rugby) in succession to Mr. J. G. Boddy. Mr. J. W. Ward has been appointed assistant sales manager (Rugby). Mr. D. R. S. Turner has been appointed divisional commercial manager. Mr. R. R. Whyte has been appointed divisional manufacturing manager, retaining his existing appointment as assistant works manager (mechanical), Trafford Park. Mr. W. T. H. Golding has been appointed works manager (Larne Works), and Mr. R. O. Knight, superintendent.

Business Announcements

ANCORITE, Ltd., has moved to larger premises at 2–4, Ladbrook Road, South Norwood, London, S.E.25 (telephone: Livingstone 6616).

MESSRS. R. TRAVERS MORGAN AND PARTNERS, Hulton House, 161/6, Fleet Street, London, E.C.4, announce that Mr. L. Scott White is retiring, but is being retained as consultant.

METAL PROTECTION PRODUCTS, Ltd., Wrencote House, High Street, Croydon, Surrey, announces that it is now the sole selling agent in the United Kingdom for Wynn's friction proofing products, formerly handled by F. U. (London), Ltd.

SIMON-CARVES, Ltd., states that its offer to acquire the whole of the issued share capital of Lodge-Cottrell, Ltd., has been accepted by all the shareholders and has become unconditional, and arrangements are accordingly being made to complete the transaction.

SAUNDERS-ROE, Ltd., has announced that it has entered into an agreement with Helicop-Air, Paris (the European Agents for Hiller Aircraft Corporation, California), to build a number of Hiller XROE-1 one-man helicopters. A number of the completed Rotorcycles will be sent to America for evaluation by the American Services.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., announces that its offices at 1–3, St. Paul's Churchyard, E.C.4, will be moved to 33, Grosvenor Place, London, S.W.1 (telephone, Belgravia 7011), on November 24; the new address will come into force for Metropolitan-Vickers Electrical Export Company, Ltd., on December 1.

THE LIGHTFOOT REFRIGERATION COMPANY, Ltd., Wembley, Middlesex, and Gesellschaft für Linde's Eismaschinen A.G., Wiesbaden, Germany, announce that they have signed an agreement for mutual collaboration whereby the products and technical resources of each company in the field of domestic and industrial refrigeration and air conditioning will be made available to the other.

Contracts

KEIR AND CAWDER ARROW DRILLING (U.K.), Ltd., has been awarded a two-year contract by Basrah Petroleum Company, Ltd., for drilling oil wells in the Rumaila Field of Southern Iraq. Keir and Cawder Arrow Drilling will take into Iraq two new heavy deep-well drilling rigs with all equipment, and trailer camps for staff. On completion of each well, which will be drilled to about 11,000ft depth, the complete rig will be moved across the desert by jacking on to tracks and hauling by tractors.

ELLIOTT BROS. (LONDON), Ltd., a member of the Elliott-Automation Group, has been awarded a contract by the Central Electricity Generating Board for the design and manufacture of a Nuclear Power Station Simulator. The simulator will be used for training operators for the Berkeley and Bradwell power stations and for similar stations subsequently. It consists, in effect, of a replica of the main control desk and will simulate not only the reactor itself but blowers, heat exchangers, &c. The simulator will be able to reproduce abnormal working conditions, a facility which will be under the control of an instructor provided with a special panel out of sight of the trainee. The simulator is to be installed at Berkeley in the middle of 1959.

Miscellanea

BENDING BERYLLIUM TUBES.—We learn that the Tube Investments Technological Centre at Walsall has fabricated a small bore beryllium tube of sufficient ductility to permit bending it on a 5in radius. The tube is of 0·300in bore with a wall thickness of 0·040in.

FORESTRY MACHINERY COMPETITION.—The Royal Agricultural Society of England has recently completed a competition for "new machines of special application to forestry." The object of this competition has been to reveal new methods and machines for the conversion of thinnings into saleable form, or improved machines for cross-cutting and/or peeling poles for pit props or chipping poles for wood pulp. Eight machines were accepted for the competition and the final awards of the judges were made known at a demonstration in Oxfordshire on November 6. Silver medals are being awarded to Cundeys, Ltd., for a de-barking machine and to F. W. McConnel, Ltd., for a mobile saw. Awards of bronze medals are made to the Forestry Commission for a self-propelled "sulky," to Gopsill Brown Trading Company, Ltd., for a self-powered saw, and to F. W. McConnel, Ltd., for a timber arch and capstan. All these machines will be exhibited at the Royal Show at Oxford in July, 1959.

THE AEROPLANE.—Three Cantor lectures on "The Aeroplane" will be delivered to and at the Royal Society of Arts, John Adam Street, London, W.C.2, at 6 p.m. on Mondays, November 24, December 1 and December 8. C. H. Gibbs-Smith, M.A., F.M.A., will speak on "The Birth of the Aeroplane," P. W. Brooks, B.Sc. (Eng.), A.C.G.I., A.F.R.Ae.S., on "The Development of the Aeroplane," and E. Mensforth, C.B.E., M.A., M.I.Mech.E., F.R.Ae.S., on "The Future of the Aeroplane."

MOTOR VEHICLE STATISTICS.—The November, 1958, *Monthly Statistical Review* of the Society of Motor Manufacturers and Traders, Ltd., includes a table of the leading export markets by value for the first nine months of 1958. For cars, the United States of America predominates, taking £44,749,000, 41 per cent of the total: the only other country outside the Commonwealth to appear in the first eight is Sweden, £6,000,000. For commercial vehicles, destinations are again principally Commonwealth, Denmark appearing seventh at £2,000,000. The Scandinavian countries appear prominently in the markets for agricultural tractors, Sweden, Denmark and Finland being third, fourth and fifth: Brazil, W. Germany and Italy also appear in the first ten. Tractor sales amounted to £44,800,000, averaging more than £500 each.

DIFFUSION PUMPS.—A new diffusion pump introduced by the Metropolitan-Vickers Electrical Company, Ltd., has been designed primarily to give its highest pumping speeds at the lower pressures. This makes the pump very suitable for the large vacuum systems used in nuclear physics research, and did, in fact, form the basis of the high vacuum system supplied by Metropolitan-Vickers for the evacuation of the "Zeta" torus. Both oil and mercury versions of the pump are available and its characteristics are those of a 14in diameter pump at pressures below 5×10^{-4}mm Hg, and of a 9in diameter pump at higher pressures (of the order of 10^{-3}mm Hg). The power consumption is only 2·5kW for the oil pump version and 3kW for the mercury pump model. The peak, unbaffled air speed of the oil pump is stated to be 2850 litres per second.

DUNGENESS NUCLEAR POWER PROJECT PUBLIC INQUIRY.—The Minister of Power has instituted a public inquiry, under the provisions of subsection 1 of Section 34 of the Electricity Act, 1957, into the proposal by the Central Electricity Generating Board to build a nuclear power station at Dungeness in Kent. The public inquiry will be held at the Lydd War Memorial Hall, Station Road, Lydd, starting at 10.30 a.m. on Tuesday, December 16, 1958, and subsequent days if necessary. The inquiry will also deal with objections which have been received to transmission lines proposed to run from Dungeness to a substation at Lydd, and with objections to a compulsory purchase order which has been made in connection with the projected power station. The Minister of Power has appointed Mr. H. W. Grimmitt, chief engineering inspector to the Ministry of Power, and Mr. W. A. Devereux, F.R.I.B.A., A.A.Dip., senior planning inspector, Ministry of Housing and Local Government, to hold the inquiry.

LONGITUDINAL STRENGTH OF TANKERS.—A paper entitled "Longitudinal Strength of Tankers" was presented by Mr. J. M. Murray before the North East Coast Institution of Engineers and Shipbuilders on November 14. The paper describes the practice adopted by Lloyd's Register for determining the section modulus of large tankers and the sagging condition is noted as being the critical one. Account is taken of both the still-water and wave bending moments and the paper indicates the basis adopted for determining these two components and the stresses associated with them. Wave proportions are discussed, also the bending and shear stresses and the procedure for the adjustment of the section modulus. Some remarks are made upon the effect of design on the still-water bending moments, on the disposition of the material in the 'midship section and on the local strength of the main hull girder. In conclusion, the paper points out that the homogeneously loaded condition has been taken for strength determination as being a realistic condition and that the scheme of loading or ballasting adopted must be carefully considered. This is emphasised by the fact that in the experience of Lloyd's Register all tankers which have broken in two were subjected to a still-water stress greater than would have been set up by judicious loading.

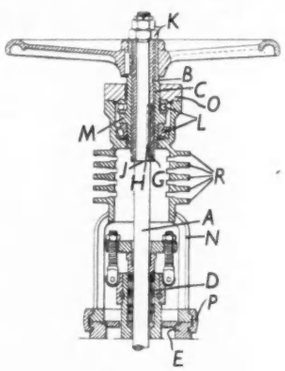
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

VALVES

802,493. March 21, 1956.—STOP VALVES, Dewrance and Co., Ltd., 165, Great Dover Street, London, S.E.1.

The invention relates to stop valves suitable for use at high temperatures. In stop valves for use with steam superheated to temperatures over 550 deg. Cent. the necessity of employing materials able to withstand the high temperatures leads to the use of austenitic steel for the valve spindles. With a valve spindle of austenitic steel running in a spindle nut of ferritic steel, however, the difficulty arises that, owing to the relatively great coefficient of thermal expansion of austenitic steel, the thread on the spindle tends to bind in the spindle nut, with consequent stripping of the thread. In order to avoid the danger of such an occurrence it is known to form a valve spindle in two parts, an austenitic part carrying the parallel slides or other movable valve element and a threaded, ferritic part, the two parts being joined by a coupling. By the invention the necessity for a spindle divided in its length is avoided. As shown in the drawing, a valve spindle *A* of austenitic steel is provided with a sleeve *B* of ferritic steel with a thread in engagement with the complementary thread of a spindle nut *C* of ferritic steel. The spindle passes



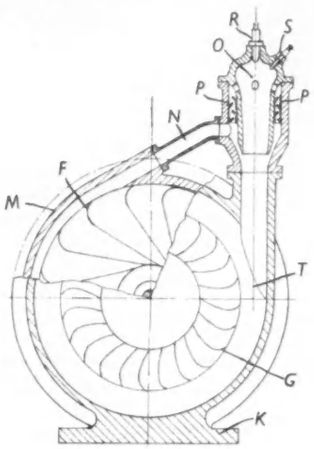
No. 802,493

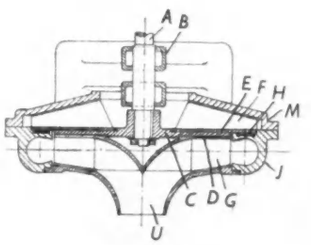
through a stuffing box *D* forming part of a closure means for an aperture *E* in a valve body of austenitic steel and at its inner end carries the parallel slides or closure members of the valve. The sleeve *B* is formed internally with a keyway *G* and relative rotation between the sleeve and the spindle is prevented by a key *H*. The sleeve *B* is positioned on the spindle between an annular shoulder *J* and a nut and lock nut *K*. The spindle nut *C* is rotatably mounted on ball and roller bearings *L* provided at opposite sides of an annular flange *M* on the spindle nut and contained within a housing which is provided at the end of and forms part of a ferritic steel bridgepiece *N* remote from the valve body and which is closed by a cover *O*. The bridgepiece *N* is secured to the valve body *F* by a split ring *P* and is air cooled by fins *R*. Since the spindle nut *C* and the threaded sleeve *B* are both of ferritic steel, the requisite relative sliding between the threads is obtained. Moreover, heat conducted through the spindle *A* is dissipated by the fins *R*, with the result that the spindle nut *C* and the sleeve *B* are effectively cooled.—*October* 8, 1958.

TURBINES

802,477. October 3, 1955.—HOT AIR TURBINES, John Johnston, "Threeways," West Runton, Cromer, Norfolk.

The invention relates to hot air turbines and its object is to provide a simply arranged apparatus and it is characterised in its method of operation by the use of injected jets of fuel gasified or sprayed by an injector into a stream of air having the flow energised by a fan and then igniting the fuel to accelerate the flowing air into impulses to operate upon a turbine wheel with driving force, this force being continued by the rapid successive explosions. In the described arrangement there is a shaft or spindle *A* mounted in bearings *B* and on the end of this shaft is attached a disc *C*, in this case overhung beside the inner bearing. On the face of this disc a turbine wheel *D* is secured and at the back of the disc a fan wheel *E* is also secured. The vanes *F* of the fan are isolated from direct air leakage by packing *H*. Both wheels are enclosed in a combined casing, the part *J* surrounding the turbine wheel being attached to the base *K* which also carries a bearing support, while the fan casing *M* is secured to its inner face. This fan casing is of snail construction and takes its air from around the bearings and discharges it tangentially into a tubular passage *N* leading to the combustion chamber *O* and to the turbine. At the combustion chamber this passage divides into two, one going up





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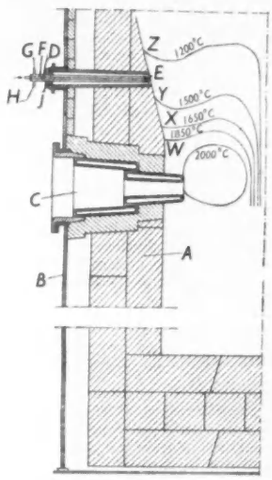
into and through the chamber, while the other stream is by-passed downward to rejoin the first stream at the combustion chamber exit. The air that flows through the combustion chamber passes first through a reaction check *P* of labyrinth formation, using forward angled vanes which hold against any suddenly applied back pressure and from this it is guided into a bulbous formation point where the fittings are arranged for the fuel injector *R* and the ignition plug *S* to produce explosion. From this point the passage straightens out and develops into an injector formation where the passages rejoin in a single one leading tangentially straight into the ring-shaped vortex channel *T* surrounding the turbine wheel upon which the hot air operates, passing out by the exhaust *U*.—*October* 8, 1958.

METALLURGY

803,002. August 8, 1955.—PLANT FOR MANUFACTURING PIG IRON IN A BLAST-FURNACE, The Societe des Acieries de Pompey, Pompey (Meurthe et Moselle), France.

The invention relates to a method of manufacturing pig iron in a blast-furnace of the type wherein auxiliary means are employed to improve the output and the degree of deoxidation of the ores. According to the example shown in the drawing, there is provided at *A* the usual carbon blocks forming the inside lining of the blast-furnace, at *B* the external airtight jacket and at *C* the usual air blowing tuyeres. At a level situated above the tuyeres an injection tuyere for additional fuel is placed. This tuyere is formed of an injection tube *D* connected to a fuel source. This tube terminates at the end that emerges into the blast-furnace in a calibrated injection nipple *E*, and is housed in a sheath *F* through which steam may be passed by way of ferrules *G* and *H*. This steam is intended to heat the fuel injected into the furnace. The continuous circulation of steam is ensured by the aforementioned ferrules *G* and *H* the steam entering by *G* and escaping at *H*. The assembly described is placed by means of a stuffing box *J*, in a protecting tuyere provided with an internal water circulation for cooling. The drawing shows isotherms *W*, *X*, *Y*, *Z* of a blast-furnace. The distance between the tuyere *C* and the conduit *D* is chosen so as to avoid any cooling effect which might be produced by the fuel on the isotherm corresponding to the tuyere *C*. On the other hand, the combustion of the fuel must not affect the nozzles of the tuyeres. This position of the conduit *D* must also create an annular transition zone between the liquid and solid phases of the melted materials. As is apparent from the drawing, the injection of fuel takes place between the isotherms *Y* and *Z*. The exact position is determined experimentally as a consequence of the above considera-



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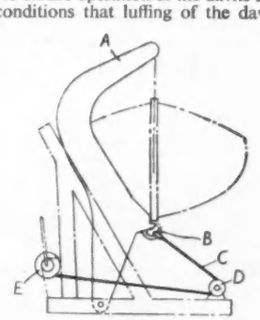
tions. The fuel nozzle is situated between the isotherms 1200 deg. and 1500 deg. Cent. in accordance with the invention. It is obvious that the degree of preheating of the auxiliary fuel introduced into the blast-furnace depends on the physical and chemical properties of the burden utilised, on the nature of the fuel use, on the level in the blast-furnace where the injection is executed, as well as on the temperature and on the oxygen content of the air blown into the tuyeres. The exact determination of the temperature is made experimentally as a consequence of the above considerations.—*October* 15, 1958.

MARINE ENGINEERING

802,961. December 28, 1955.—OPERATING GEAR FOR SHIPS' DAVITS, Davit Developments, Ltd., 14, Rutland Square, Edinburgh, 1, Scotland. (*Inventor: William Gilbert Thomson.*)

The invention relates to ships' davits of gravity type, where mechanical means are not employed for davit operation and control. The invention has for its object to ensure operation of the davits under such adverse conditions that luffing of the davit arm or



No. 802,961

arms by gravity alone might be obstructed. A further object of the invention is to ensure that the davit arms will be prevented from attaining a position of instability or commence to return before the arms reach a position in which the weight of the boat and its suspension gear will ensure completion of luffing by gravity alone. Referring to the drawing, the davit arm *A* has a hook *B*, to which is attached a ring on the end of a cable *C* which passes around a pulley *D* to a winch *E* having a winding handle. The boat is shown in the normally stowed position. If a plain hook, such as *B* is employed, the cable may detach itself automatically when the davit arm, under the influence of gravity, reaches a position where it is no longer necessary for the davit to be under the control of the starter means. In such case, when restowing the davit, the cable can be again attached to the hook and the starter winch returned to draw in the cable. By providing a suitable hook or eye on the davit arm and by attaching the cable to the hook or eye, the starter winch may be used to reship the davit from the fully luffed position, if desired. In place of a latched hook the cable may be attached to the davit arm by a shackle or other connection. In addition, four different embodiments of the invention are shown in the specification.—*October* 15, 1958.

Launches and Trial Trips

NORTH LORD, oil tanker ; built by the Blythswood Shipbuilding Company, Ltd., for Priam Compania Naviera S.A., Panama ; length between perpendiculars 535ft, breadth 71ft 8in, depth moulded 39ft, draught 30ft, deadweight 18,500 tons ; twenty-seven cargo oil tanks, two pump rooms, four 500 tons per hour pumps ; two 300kW diesel-driven generators, one 100kW steam-driven generator ; Rowan-Doxford supercharged oil engine, six cylinders, 650mm diameter by 2320mm combined stroke, arranged to burn heavy fuel, 8000 b.h.p. Launch, August 29.

TEAKBANK, cargo ship ; built by William Doxford and Sons (Shipbuilders), Ltd., Sunderland, for The Bank Line, Ltd. ; length between perpendiculars 450ft, breadth moulded 38ft 6in, depth moulded to upper deck 38ft 6in, deadweight 12,160 tons on closed deck draught ; five holds, one 25-ton, four 10-ton and ten 5-ton derricks ; Doxford opposed piston oil engine, four cylinders 700mm diameter by 2320mm combined stroke, 4800 b.h.p. Launch September 1.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Nov. 21.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "The Development of Television," R. T. B. Winn, 7 p.m.
Wed., Nov. 26.—BRIGHTON, HOVE AND DISTRICT BRANCH : New Imperial Hotel, First Avenue, Hove, "Photography in Research and Industry," W. S. Sebborn, 7.30 p.m.
Thurs., Nov. 27.—SOUTH LONDON BRANCH : Greyhound Hotel, High Street, Croydon, "Developments in Floor-Heating," K. G. Stephenson, 8 p.m.
Fri., Nov. 28.—SOUTH EAST LONDON BRANCH : Visit to Courage and Barclay's Brewery, London, 6.30 p.m. ★ STOKE AND CREWE BRANCH : Grand Hotel, Hanley, "Power Factor Correction," F. T. Bartho, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

To-day, Nov. 21.—SCOTTISH SECTION : The University, Drummond Street, Edinburgh, Repeat of lectures by G. F. Norman and D. Goodwin, 7 p.m.
Tues., Nov. 25.—SOUTH WESTERN SECTION : School of Management Studies, Unity Street, Bristol, 1, "Electronic Transducers," G. F. N. Knewstub, 7 p.m.
Wed., Nov. 26.—LONDON SECTION : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Annual General Meeting, 6 p.m.: Presidential Address, E. E. Zepler, 7.15 p.m.
Fri., Nov. 28.—SOUTH MIDLANDS SECTION : North Gloucestershire Technical College, Cheltenham, "Television Recording," P. J. Guy, 7 p.m. ★ MERSEYSIDE SECTION : University Club, Liverpool, "The First Transatlantic Telephone Cable," F. Scowen, 7 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., Nov. 26.—MIDLAND REGION : Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, "Shell Type Boilers—Lancashire and Various Types of Economic Boilers—Their Ratings, Efficiencies and Heat Flow," H. E. Pearsall, 10 a.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Nov. 24.—LEEDS CENTRE : British Lighting Council, 24, Aire Street, Leeds, 1, "Australian Journey," W. E. Harper, 6.15 p.m. ★ LEICESTER CENTRE : Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester, "Work of the Building Research Station," P. Petherbridge, 7 p.m.
Fri., Nov. 28.—BIRMINGHAM CENTRE : Regent House, St. Phillip's Place, Colmore Row, Birmingham, "Headlamps and Signals for Motor Cars," J. H. Nelson, 6 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Nov. 24.—WEST AND EAST YORKSHIRE BRANCH : Fuel Department, Lecture Theatre, New Building, The University, Leeds, "Rocket Propulsion and Control," D. Hurden, 7.30 p.m.
Tues., Nov. 25.—SOUTH WALES BRANCH : South Wales Engineers' Institute, Park Place, Cardiff, "Corrosion," D. W. Marshall, 7.30 p.m.
Thurs., Nov. 27.—MERSEYSIDE AND NORTH WALES BRANCH : Exchange Hotel, Liverpool, "Some Aspects of Automatic Control," R. E. Harvison, 7.15 p.m. ★ SHEFFIELD AND DISTRICT BRANCH : Grand Hotel, Sheffield, "Fire Prevention," 7.30 p.m.
Fri., Nov. 28.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, "Statutory Regulations of Steam and Pressure Vessels," 7.30 p.m.

INDUSTRIAL WELFARE SOCIETY

Fri. to Mon., Nov. 21 *to* 24.—Grand Hotel, Brighton, Conference on "Management Priorities in the Office."

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Nov. 25.—SLOUGH SECTION : Lecture Theatre, High Duty Alloys, Ltd., Slough, "£.s.d. in the Foundry," G. B. Judd, 7.30 p.m.
Wed., Nov. 26.—SOUTHAMPTON SECTION : Technical College, St. Mary's Street, Southampton, Films, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Nov. 24.—SOUTH WALES SECTION : Welsh College of Advanced Technology, Cathays Park, Cardiff, "Gas Turbines," D. L. Brown, 7 p.m.
Wed., Nov. 26.—MERSEYSIDE AND NORTH WESTERN SECTION : Technical College, Birkenhead, "Gas Turbines," D. L. Brown, 7.15 p.m. ★ SIR CHARLES PARSONS MEMORIAL LECTURE : Memorial Building, 76, Mark Lane, London, E.C.3, "Recent Advances in Nuclear Engineering," Sir John D. Cockcroft, 5.30 p.m.
Fri., Nov. 28.—SOUTH WALES SECTION : Technical College, Swansea, "The Duties in the Day of a Seagoing Engineer," T. C. Bishop, 2 p.m.

INSTITUTE OF NAVIGATION

To-day, Nov. 21.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Navigating Across the Antarctic," George Lowe, 5.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Nov. 25.—LONDON BRANCH : Geological Society, Burlington House, London, W.1, "A Suggested Equation Relating to the Mixing of Powders and its Application to the Study of the Performance of Certain Types of Machine," H. E. Rose, 5.30 p.m. ★ NORTH WESTERN BRANCH : Technical College, Birkenhead, "Pollution Law and the Chemical Engineer," R. R. Ferner, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

To-day, Nov. 21.—MIDLANDS ASSOCIATION : Midland Institute, Paradise Street, Birmingham, 1, "Operational Experience at Calder Hall," K. L. Stretch, 6.30 p.m.
Tues., Nov. 25.—Great George Street, Westminster, London, S.W.1, "A Study of Traffic Flow : Its Seasonal Variation, and Relation to Traffic Capacity Standards, with Special Reference to Parts of Dorset," J. I. Whitehead, 5.30 p.m.
Thurs., Nov. 27.—NORTH WESTERN ASSOCIATION : Queen Hotel, Chester, "The Layout of Roundabouts in Rural Areas," A. G. Tyson, 7.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Nov. 21.—S. MIDLAND CENTRE : Midland Institute, Birmingham, "Operational Experience at Calder Hall," K. L. Stretch, 6.30 p.m. ★ N. STAFFORDSHIRE SUB-CENTRE : Technical College, Stoke-on-Trent, "Electrical Floor Warming," J. W. Moule and W. M. Stevenson, 7 p.m. ★ N.E. CENTRE : Technical College, Carlisle, "Some Aspects of Heat Pump Operation in Great Britain with particular reference to the Shinfield Installation," Miriam V. Griffith, 7 p.m.
Mon., Nov. 24.—RADIO AND TELECOMMUNICATION SECTION : Savoy Place, London, W.C.2, "The Use of Dispersive Dielectrics in a Beam-Scanning Prism," J. S. Seeley and J. Brown; "The Quarter-Wave Matching of Dispersive Materials," J. S. Seeley, and "Theory of Reflections from the Rodded-Type Artificial Dielectric," A. Carne and J. Brown, 5.30 p.m. ★ EAST MIDLAND CENTRE : E.M.E.B. Service Centre, Derby, The Importance of Research in Hearing and Seeing to the Future of Telecommunication Engineering," E. C. Cherry, 6.30 p.m. ★ EAST ANGLIAN SUB-CENTRE : Crown and Anchor Hotel, Ipswich, "British Columbia-Vancouver Island 138kV Submarine Power Cable," T. Ingledow, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson, 6.30 p.m. ★ MERSEY AND NORTH WALES CENTRE : Town Hall, Chester, "The Recognition of Moving Vehicles by Electronic Means," T. S. Pick and A. Readman, 6.30 p.m. ★ NORTH-EASTERN CENTRE : Neville Hall, Westgate Road, Newcastle upon Tyne, "Standardization of Control Facilities for the British Grid : Communications, Indications and Telemetering," P. F. Gunning ; "The Development of Communication, Indication and Telemetering Equipment for the British Grid," G. A. Burns, F. Fletcher, C. H. Chambers and P. F. Gunning, 6.15 p.m. ★ SOUTH MIDLAND RADIO AND MEASUREMENT GROUP : James Watt Memorial Institute, Birmingham, "The Development of a Guided Missile," W. R. Thomas, 6 p.m. ★ WESTERN UTILIZATION GROUP : Electricity House, Colston Avenue, Bristol, "Electrical Installations in Highly Automatic Industrial Plants," F. A. Richmond, 6 p.m. ★ READING DISTRICT BRANCH : George Hotel, King Street, Reading, "American Electricity Supply Practice," R. H. Abell, 7.15 p.m.
Tues., Nov. 25.—CHELMSFORD DISTRICT BRANCH : Public Library, Chelmsford, "A Review of Industrial Ultrasonics," R. D. Foskett and D. H. Hardy, 7 p.m. ★ NORTH MIDLAND CENTRE : Institute of Technology, Bradford, Discussion on "The Teaching of Nuclear Engineering for Power Generation," opened by A. D. Collop, 6.30 p.m. ★ NORTH-WESTERN SUPPLY GROUP : Engineers' Club, Albert Square, Manchester, "The Design of the 330kV Transmission System for Rhodesia," F. C. Winfield, T. W. Wilcox and G. Lyon, 6.15 p.m. ★ WEST WALES (SWANSEA) SUB-CENTRE : Brangwyn Hall, Swansea, Faraday Lecture, "Automation," H. A. Thomas, 6 p.m.
Wed., Nov. 26.—LONDON GRADUATE AND STUDENT SECTION : Visit to Fraser and Chalmers Engineering Works, Erith, 2 p.m. ★ SUPPLY SECTION : Savoy Place, London, W.C.2, "Investigations of Power-Follow Current Phenomena Using a Synthetic Power Source," L. L. Alston and Professor F. M. Bruce, and "The Impulse Initiation of Arc Discharges," L. L. Alston, 5.30 p.m. ★ SOUTH-WEST SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Supply-Voltage and Current Variations Produced by a 60-Ton Three-Phase Electric Arc Furnace," B. C. Robinson and A. I. Winder, 7 p.m. ★ SOUTH MIDLAND CENTRE : College of Technology, Gosta Green, Birmingham, Discussion on "Modern Industrial Applications of Field Plotting," opened by E. R. Hartill, 6.15 p.m. ★ RUGBY SUB-CENTRE : College of Technology, Rugby, "Thermo-Nuclear Reactions," S. Kaufman, 6.30 p.m. ★ SOUTHERN CENTRE : R.A.E. Technical College, Farnborough, "Operational Experience at Calder Hall," K. L. Stretch, 6.30 p.m.
Thurs., Nov. 27.—UTILIZATION SECTION : Savoy Place, London, W.C.2, Symposium, "The Provision of Adequate Electrical Installations in Buildings," 2.30 p.m. and 5.30 p.m. ★ WESTERN CENTRE : Colston Hall, Bristol, Faraday Lecture, "Automation," H. A. Thomas, 6.45 p.m.
Fri., Nov. 28.—SOUTHERN CENTRE : South Dorset Technical College, Weymouth, "The Design of Transistors," J. R. Tillman, 6.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Wed., Nov. 26.—YORKSHIRE BRANCH : Midland Hotel, Bradford, "Jodrell Bank Radio Telescope," C. N. Kington, 7.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 21.—THOMAS HAWKSLEY LECTURE : 1, Birdcage Walk, Westminster, London, S.W.1, "Transmission of Acoustic Waves Through Structures," Leo L. Beranek, 6 p.m. ★ WESTERN GRADUATES' SECTION : Engineering Laboratories, The University, University Walk, Bristol, 8, "Small Centripetal Turbines for Aircraft Drives," M. J. Whitmarsh-Everiss, 7.15 p.m.
Sat., Nov. 22.—LONDON GRADUATE SECTION : Visit to Vickers-Armstrongs (Aircraft), Ltd., Weybridge, 9.30 a.m. ★ MIDLAND GRADUATE SECTION : Morning Visit to Cincinnati Milling Machines, Ltd., Kingsbury Road, Erdington, Birmingham.
Mon., Nov. 24.—EAST MIDLANDS BRANCH AND DERBY A.D. CENTRE : Rolls-Royce Welfare Hall, Derby, "Some Aspects of Reactor Design for Ship Propulsion," J. S. Hollings, 6.15 p.m.
Tues., Nov. 25.—LONDON AUTOMOBILE DIVISION : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Accessibility in Vehicle Design," 6 p.m. ★ YORKSHIRE BRANCH : Institute of Technology, Bradford, Discussion on "Teaching of Nuclear Engineering for Power Generation," introduced by A. D. Collop, 6.30 p.m.
Wed., Nov. 26.—PARSONS MEMORIAL LECTURE : Institute of Marine Engineers, 76, Mark Lane, London, E.C.3, "Recent Advances in Nuclear Engineering," Sir John D. Cockcroft, 5.30 p.m. ★ NORTH WESTERN BRANCH (BLACKBURN PANEL) : Lecture Hall, Central Library, Grimshaw Street, Burnley, "Machine Tool Developments in the U.S.S.R.," Norman Stubbs, 7 p.m. ★ SOUTHERN BRANCH : Technical College, Reading, Berks, "Vacuum Techniques in the Atomic Energy Industry," H. Kronberger, 7.30 p.m. ★ SOUTH WALES BRANCH : S.W. Electricity Board's Showrooms, The Kingsway, Swansea, "Large Pipeline Projects," A. C. Hartley, 6 p.m. ★ LONDON GRADUATES' SECTION : 1, Birdcage Walk, Westminster, London, S.W.1, "Possible Nuclear Reactor System for the Propulsion of Smaller Ships," A. N. Byford, 6.30 p.m.
Thurs., Nov. 27.—EASTERN BRANCH : Clarendon Laboratory, Oxford, "Transmission of Acoustic Waves Through Structures," L. L. Beranek, 7.30 p.m. ★ INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP : Engineers' Club Albert Square, Manchester, "Application of Optics in Engineering Inspection," O. C. Taylerson, 6.45 p.m. ★ YORKSHIRE BRANCH : The University, Leeds, "ZETA," A. R. Carruthers, 6.30 p.m. ★ EAST MIDLANDS GRADUATES' SECTION : Room C.4, Engineering Building, The University, Nottingham, Discussion on the Report on Practical Training, 7.15 p.m.
Fri., Nov. 28.—LONDON BRANCH : 1, Birdcage Walk, Westminster, London, S.W.1, Technical Film Show, 6 p.m. ★ NORTH EASTERN GRADUATES' SECTION : King's College, Newcastle upon Tyne, Debate, "The Benefits of Nuclear Energy are Outweighed by its Disadvantages," 6.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Nov. 21.—DERBY SECTION : Louis Room, St. James's Restaurant, St. James's Street, Derby, "The Spacematic," W. J. Adams, 7 p.m.
Mon., Nov. 24.—MANCHESTER SECTION : College of Science and Technology, Sackville Street, Manchester, "Diploma in Technology," Dr. Whitworth, 7.15 p.m. ★ STOKE-ON-TRENT SECTION : Grand Hotel, Hanley, Stoke-on-Trent, "The Use of Rubber in Engineering," A. N. Gent, 7.30 p.m.
Tues., Nov. 25.—SHREWSBURY SECTION : Walker Technical College, Oakengates, Shrewsbury, "Ceramic Cutting Tools," G. R. Conner, 7.30 p.m. ★ LOUGHBOROUGH COLLEGE STUDENTS' SECTION: Room A.1, Loughborough College, Schofield Building, Ashby Road, Loughborough, "A Modern Foundry for the Manufacture of Small Steel Castings by New Moulding Techniques," J. H. Osborn, 7.30 p.m.
Wed., Nov. 26.—WORCESTER SECTION : Victoria College, Worcester, "Spark Machining," E. A. Sweetman, 7.30 p.m.
Thurs., Nov. 27.—LINCOLN SECTION : Ruston Club, Lincoln, "Some Factors Affecting Cutting Tool Performance," R. J. Cowie, 7.30 p.m. ★ ROCHESTER GRADUATE SECTION : Sun Hotel, High Street, Chatham, "Lens Manufacture," E. Atkinson, 7.30 p.m.
Fri., Nov. 28.—CARDIFF SECTION : South Wales Institute of Engineers, Park Place, Cardiff, "Tooling with Epoxy Resins," E. M. White, 7 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Nov. 24.—MANCHESTER SECTION : Grand Hotel, Manchester, "Air Suspensions—A Tyre Engineer's Viewpoint," V. E. Gough, 6.45 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Nov. 25.—SCOTTISH BRANCH : Institution of Engineers and Shipbuilders, Glasgow, "Application of Welding to Structural Engineering," D. Watson, 7 p.m.
Thurs., Nov. 27.—LONDON BRANCH : 11, Upper Belgrave Street, London, S.W.1, "Modern Methods of Fabricating Structural Steelwork," M. F. Palmer and R. J. Fowler, 6 p.m.
Fri., Nov. 28.—MIDLAND COUNTIES BRANCH : James Watt Memorial Institute, Birmingham, "International Union of Architects 1958 Congress in Moscow," A. G. Ling, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 21.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Printed Circuit Techniques," P. A. Trigg, 7 p.m.
Fri., Nov. 28.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Annual General Meeting, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Nov. 28.—College of Science and Technology, Manchester, "Electro-Mechanical Themes in Machine Tool Design," The Rt. Hon. the Earl of Halsbury, 6.45 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Sat., Nov. 22.—STUDENT SECTION : Visit to Smith's Dock Company, Ltd., Middlesbrough.
Wed., Nov. 26.—TEES-SIDE BRANCH : Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Notes on the Longitudinal Strength of Tankers," J. M. Murray, 6 p.m.
Fri., Nov. 28.—Lecture Theatre, Mining Institute, Neville Hall, Newcastle upon Tyne, "Tests on Light Alloy Stiffener Sections," M. N. Parker, 6.15 p.m.

PLASTICS INSTITUTE

To-day, Nov. 21.—MIDLANDS SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Plastics in the Building Industry," R. P. H. Gillett, 6.30 p.m.

ROYAL SOCIETY OF ARTS

Mon., Nov. 24.—John Adam Street, Adelphi, London, W.C.2, Cantor Lecture, "The Birth of the Aeroplane," C. H. Gibbs-Smith, 6 p.m.

ROYAL STATISTICAL SOCIETY

Thurs., Nov. 27.—SHEFFIELD GROUP : Grand Hotel, Sheffield, "A New Approach to Control Chart Theory," G. A. Barnard, 7 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Nov. 25.—DATA PROCESSING SECTION : Manson House, Portland Place, London, W.1, "Digital Data-Recording for Nuclear Experiments," R. C. M. Barnes, 6 p.m.
Wed., Nov. 26.—CHESTER SECTION : Grosvenor Museum, Grosvenor Street, Chester, "Instrumentation in Chemical Analytical Control," B. W. Bradford, 7 p.m. ★ SOUTH WALES SECTION : Steel Company of Wales, Port Talbot, Glam, "Measurement and Instrumentation Applied to Atmospheric Pollution," R. A. Granville, 5.30 p.m.
Fri., Nov. 28.—SCOTTISH SECTION : Scottish Building Centre, 425, Sauchiehall Street, Glasgow, "Analytical Instrumentation of Chemical Processes," J. D. Tallantire, 7.15 p.m.

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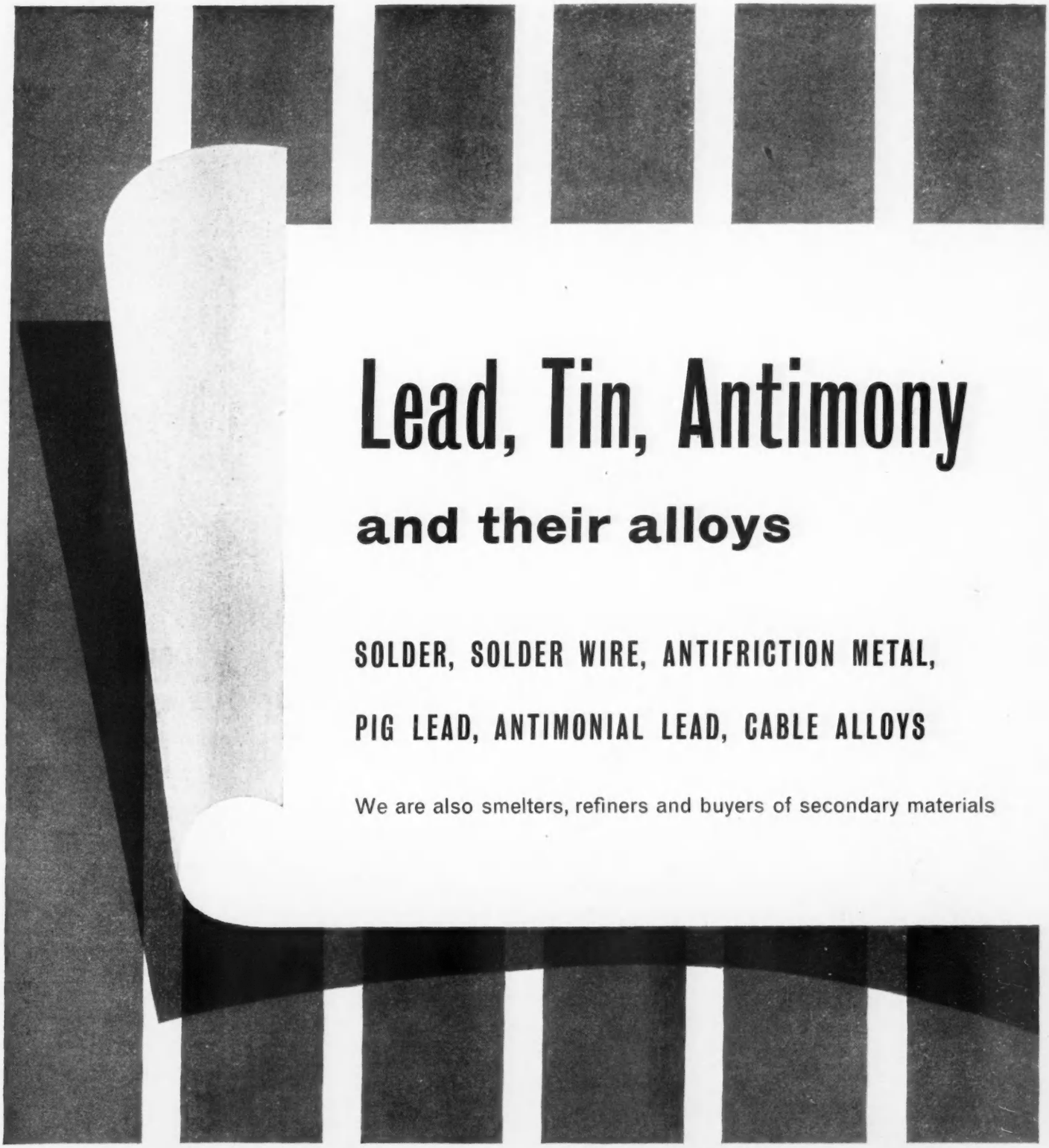

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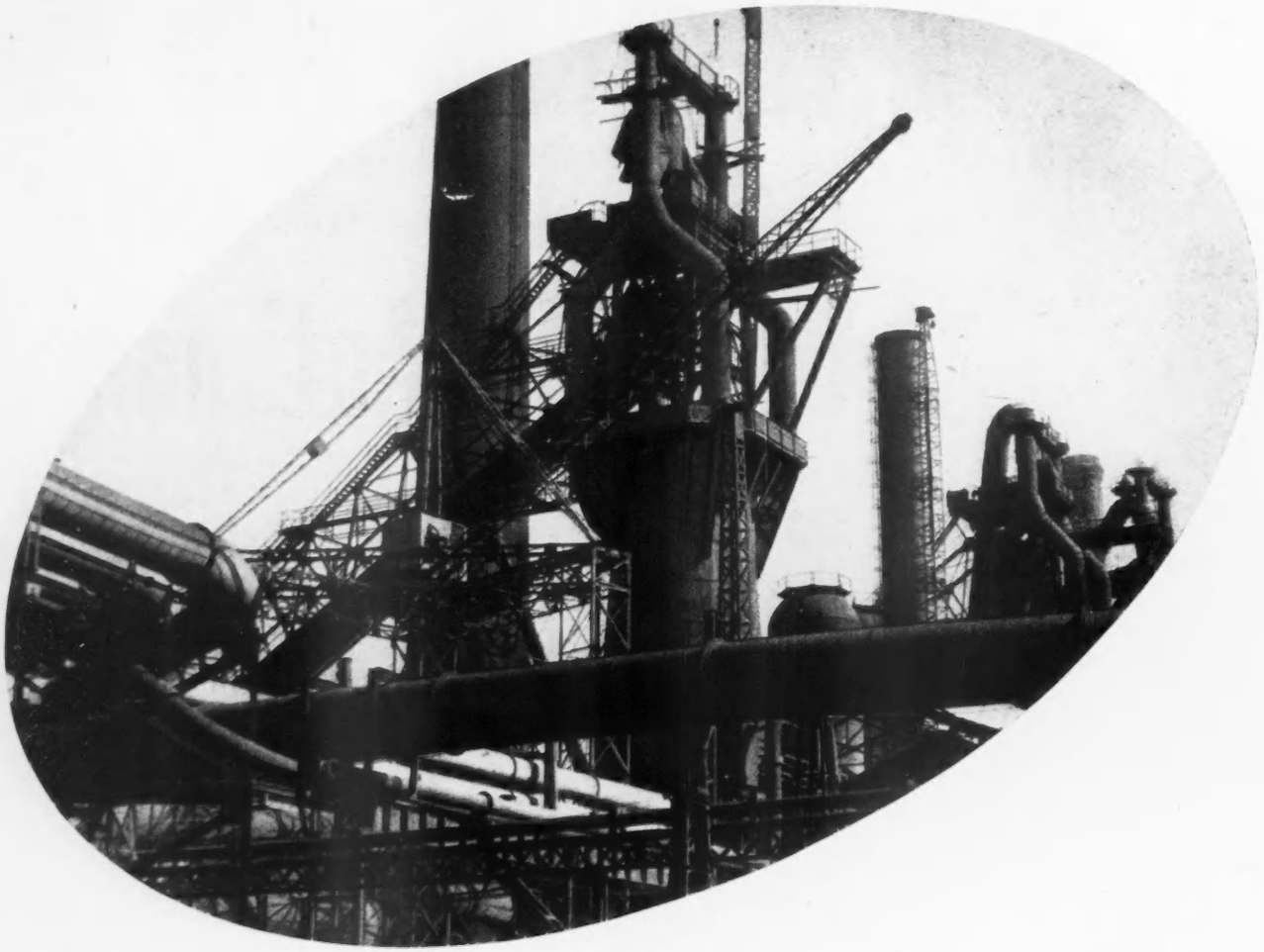

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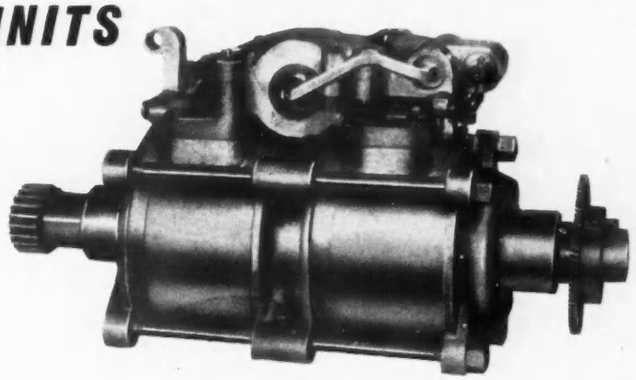

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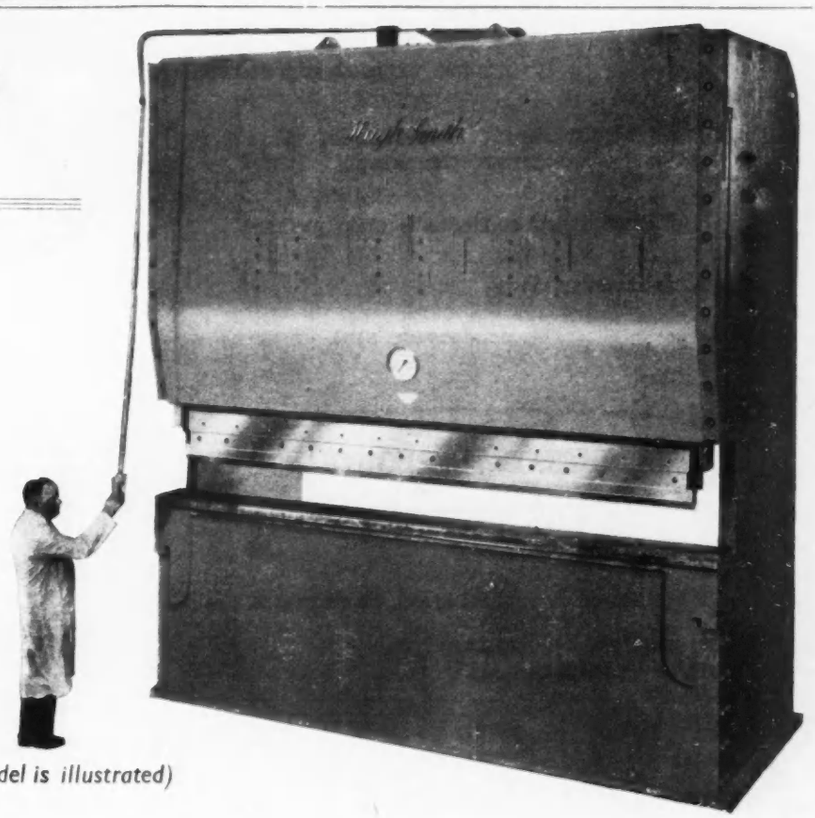

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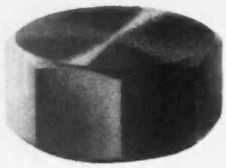

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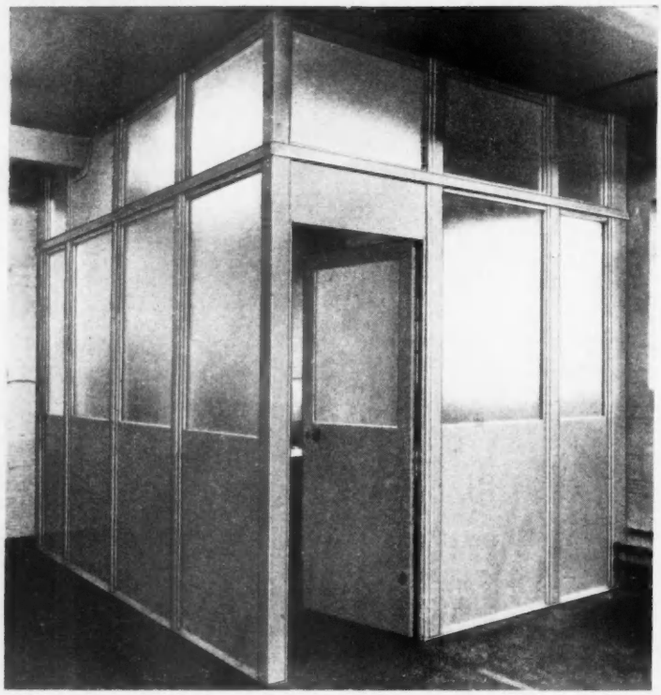

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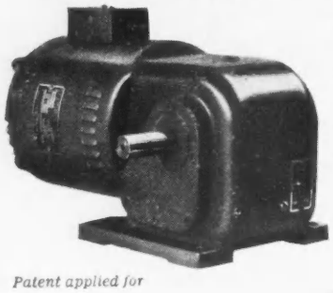

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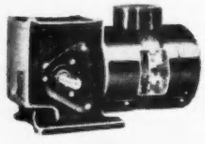

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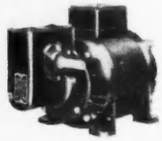

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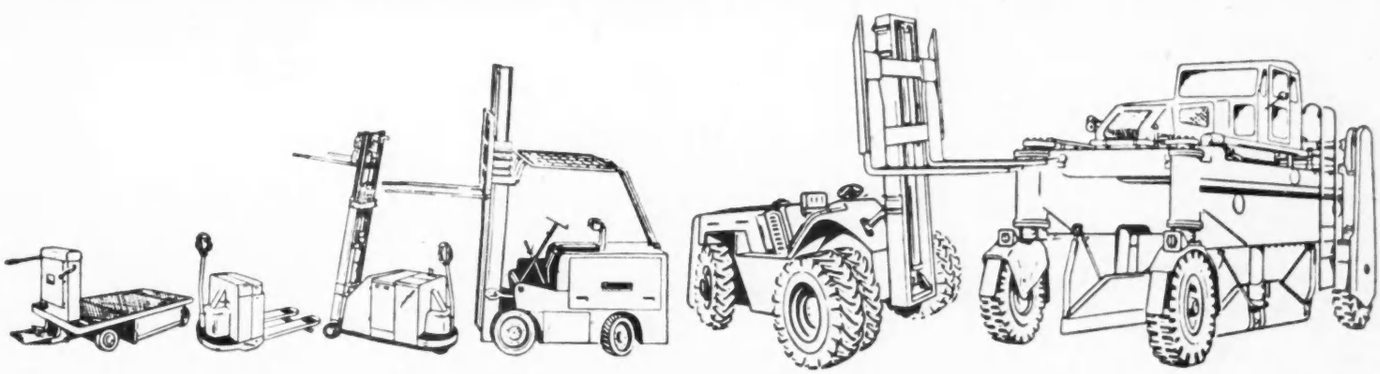

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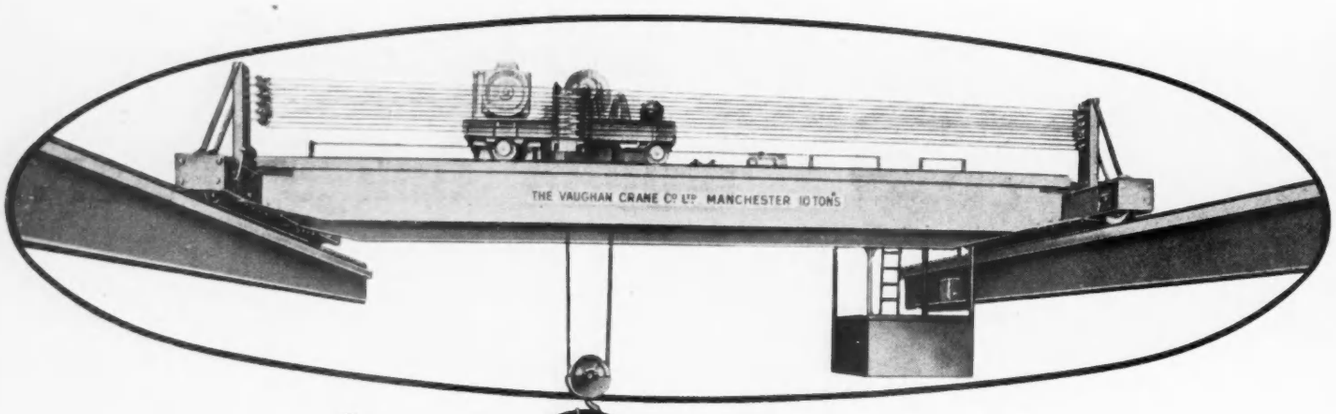

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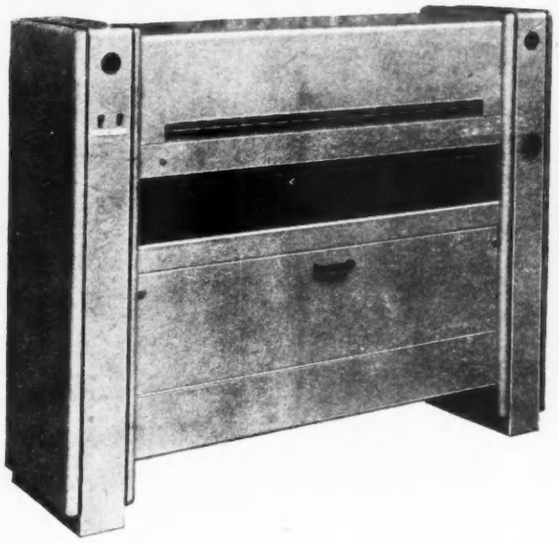

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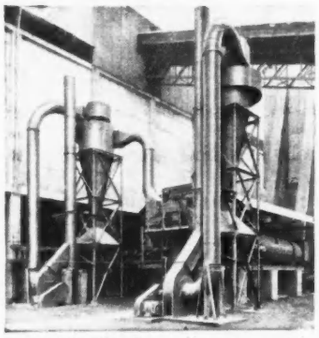

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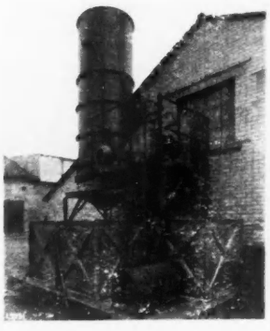

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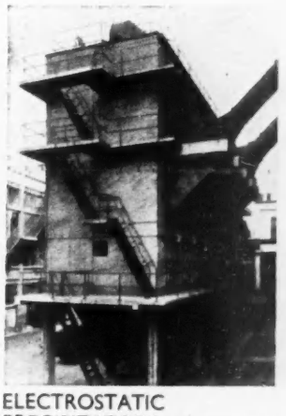

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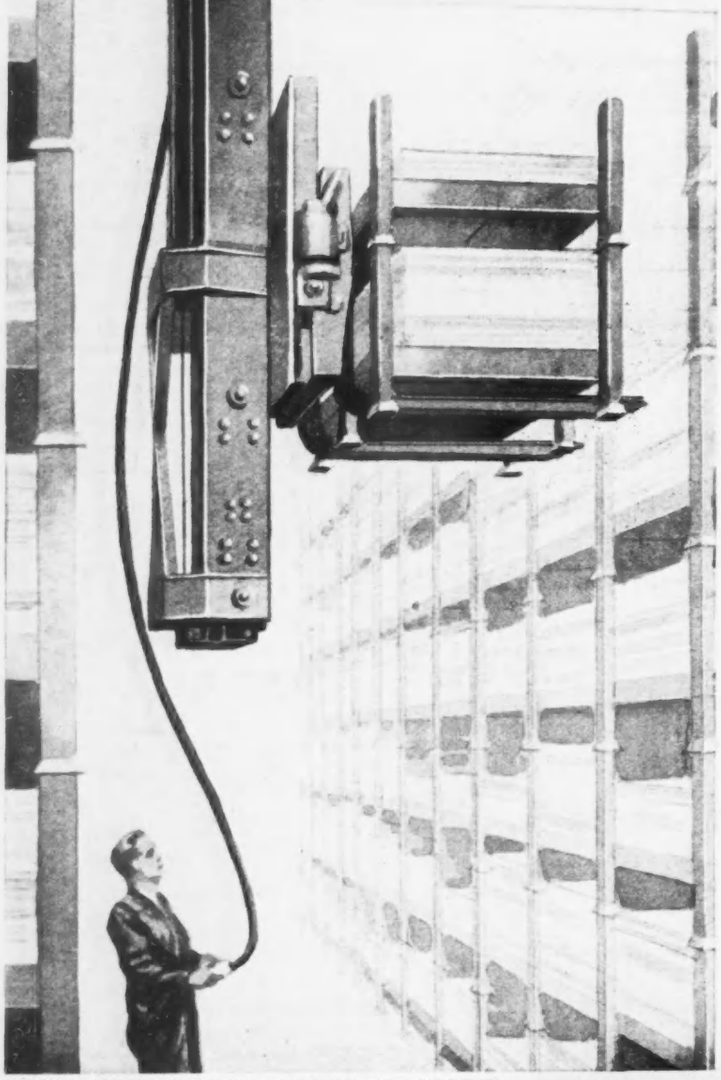

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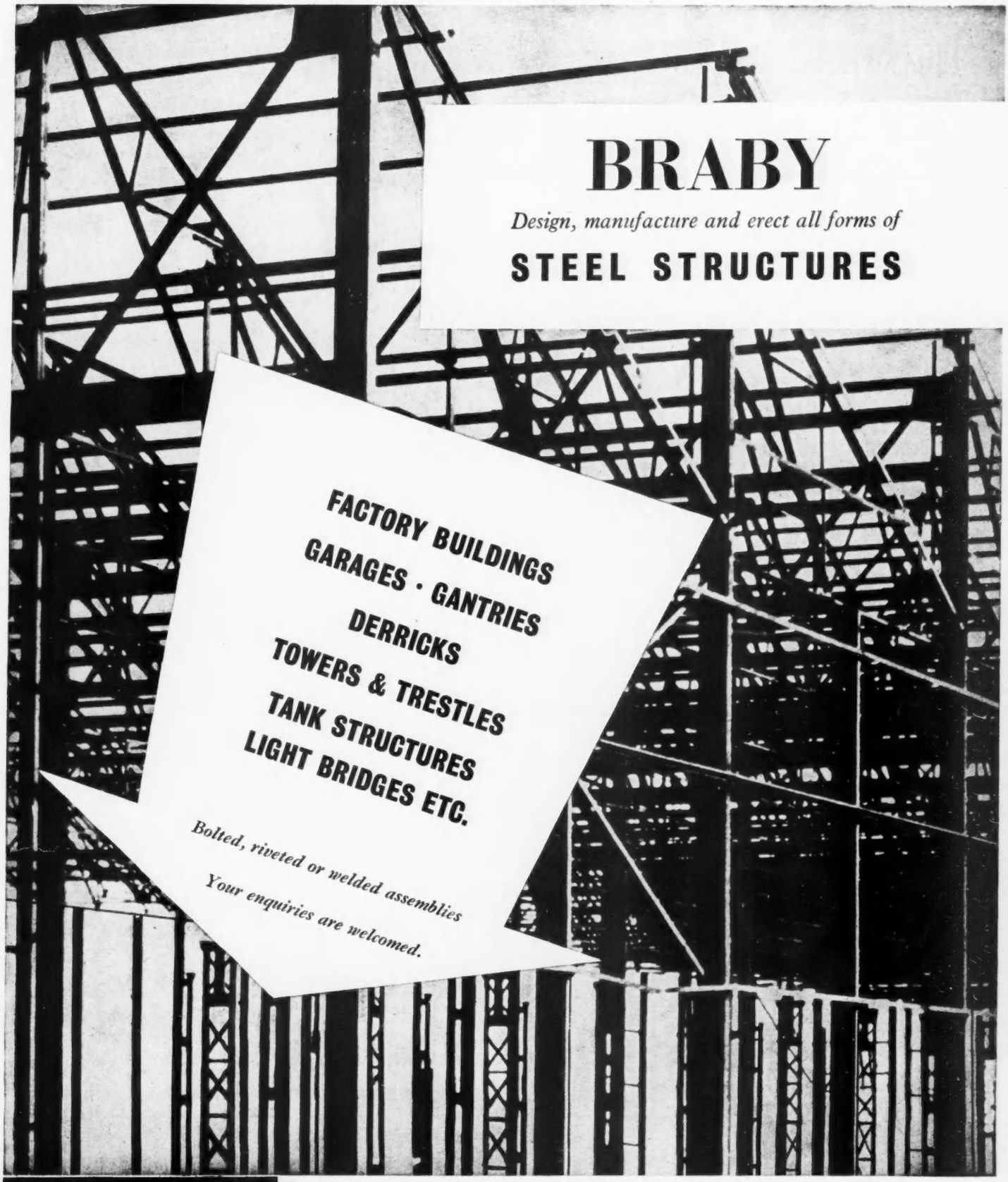

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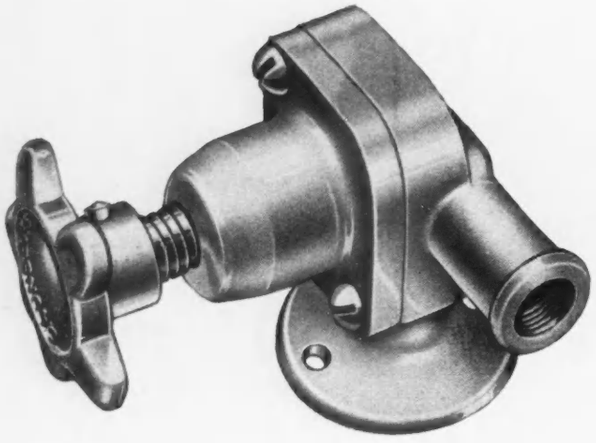

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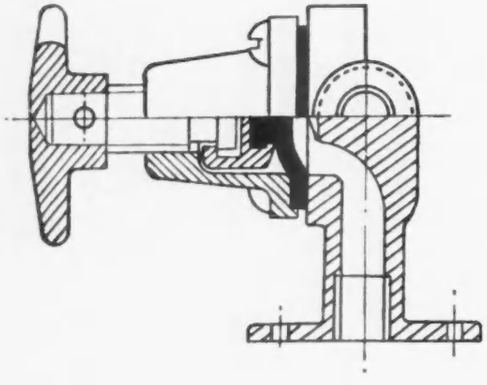

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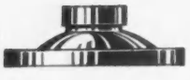

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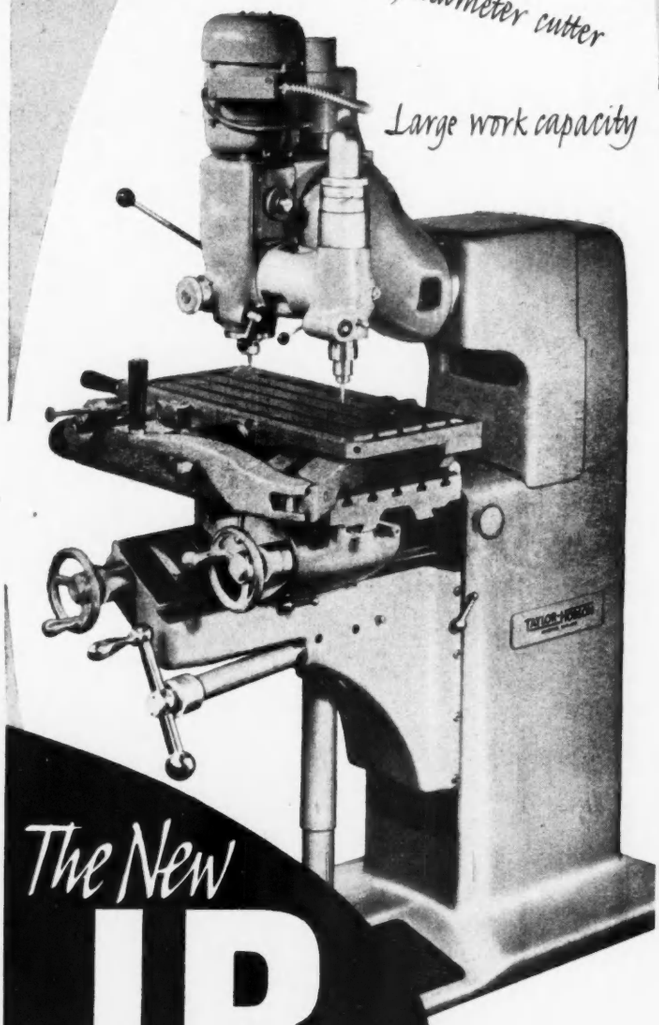

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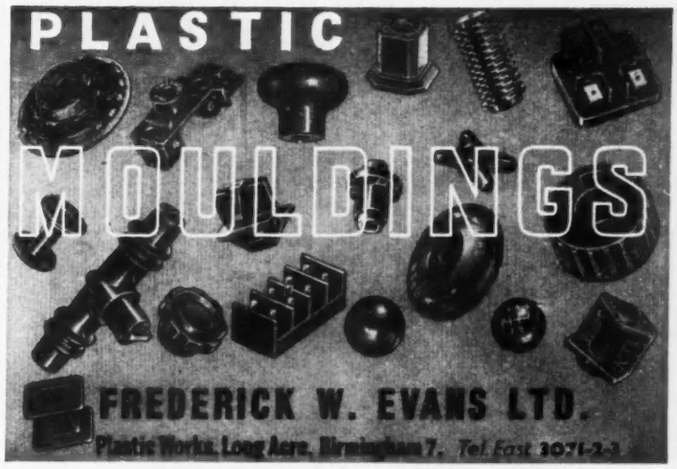

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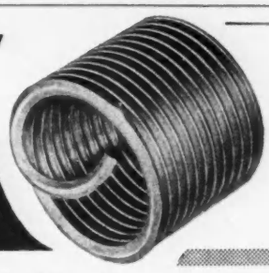

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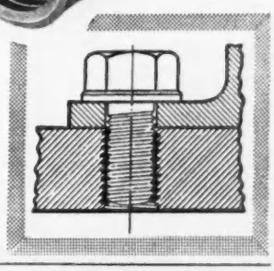

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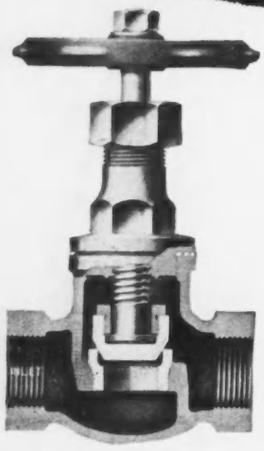

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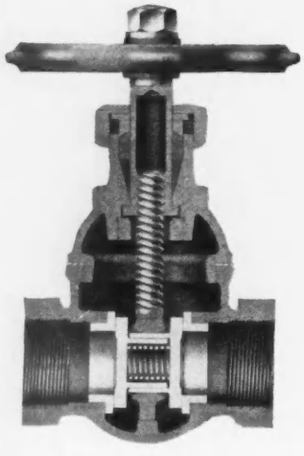

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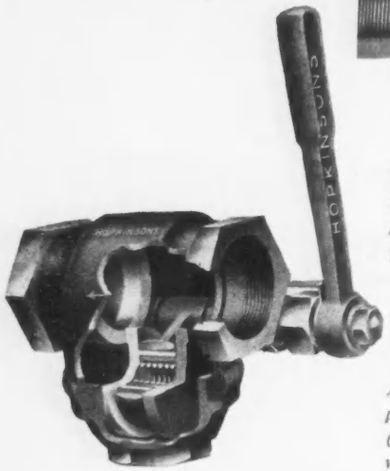

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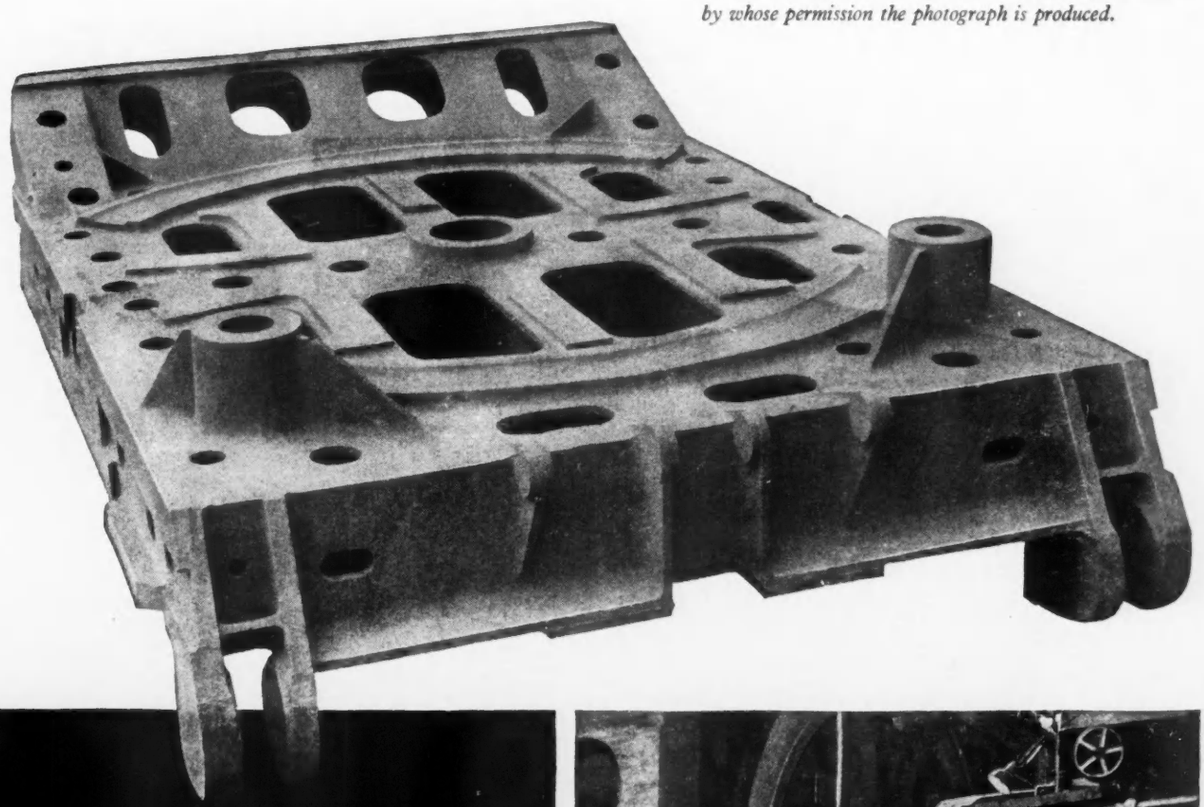
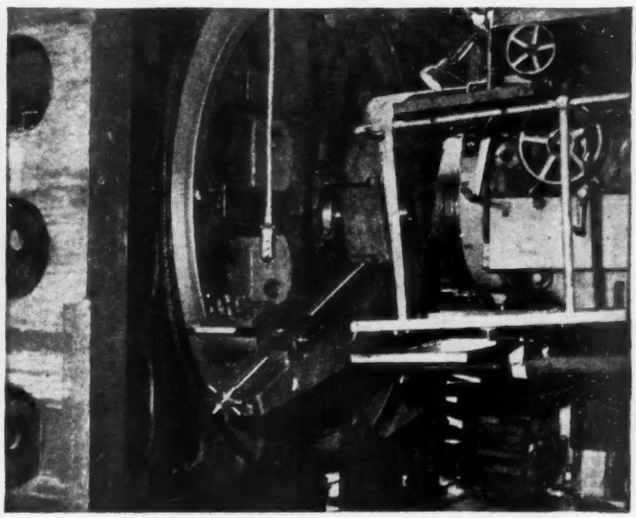
Revolving frame steel casting for the 150-RB excavator, size 10 ft. x 15ft. 6 ins. Cast for Ruston-Bucyrus Ltd. by whose permission the photograph is produced.



cast and machined for an important part



This massive revolving frame is cast in steel for the 150-RB excavator. Weighing 29 tons "as cast" it measures 10 ft. x 15 ft. 6 ins. and is a normal Lloyd production casting. It has to stand up to the severe shock loadings which are developed progressively, as when the 150-RB bites into compacted soil or loose rock that is lifted in one operation. The mould contained 80 cores and there were 21 feed heads. Co-ordinated with the casting was the machining process, a task well within the scope of Lloyds unsurpassed machine shops. The proof of a perfect casting lies in the machining, and it always operates to the advantage of the customer to allow Lloyds to machine the castings they make for him.

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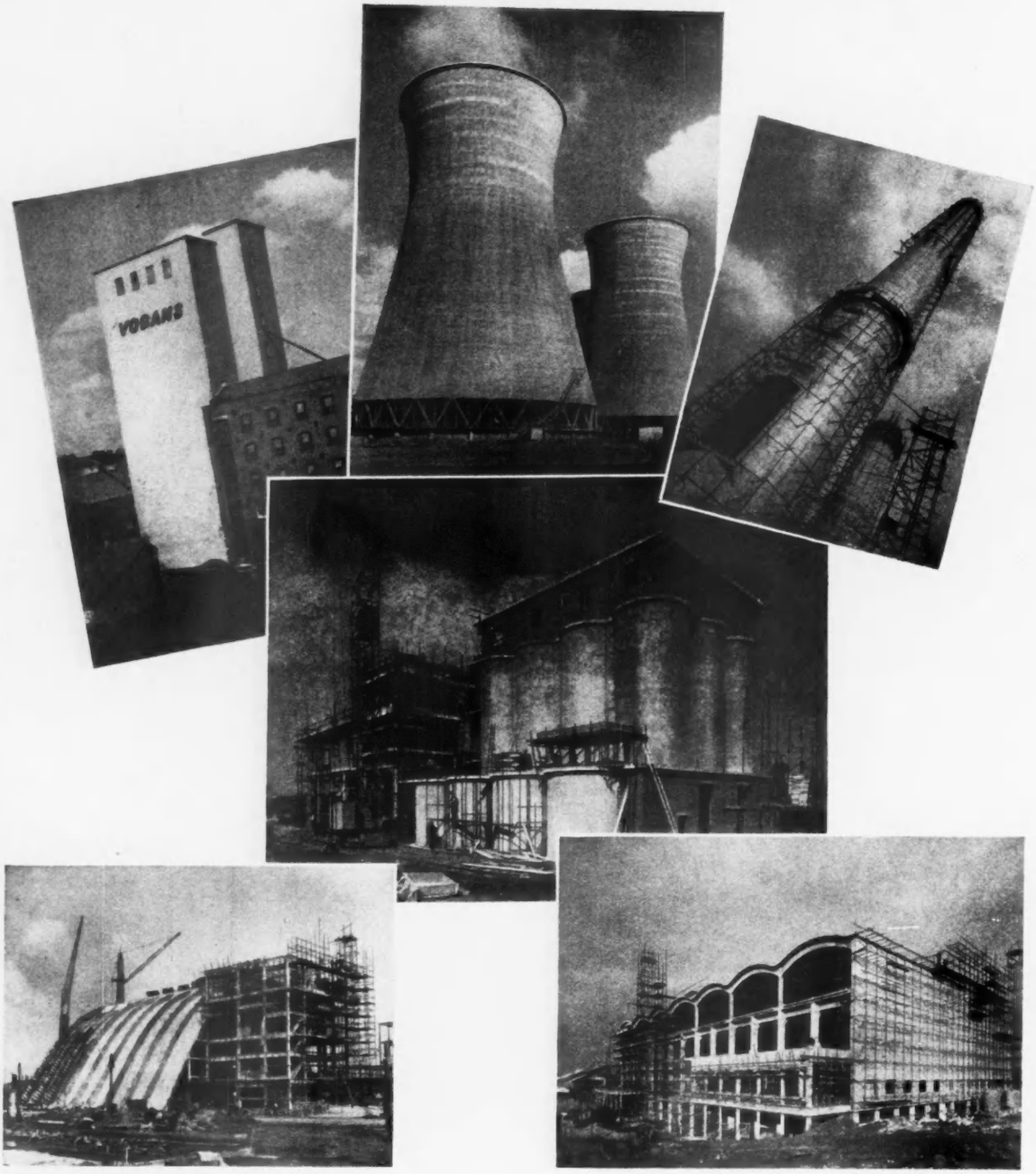

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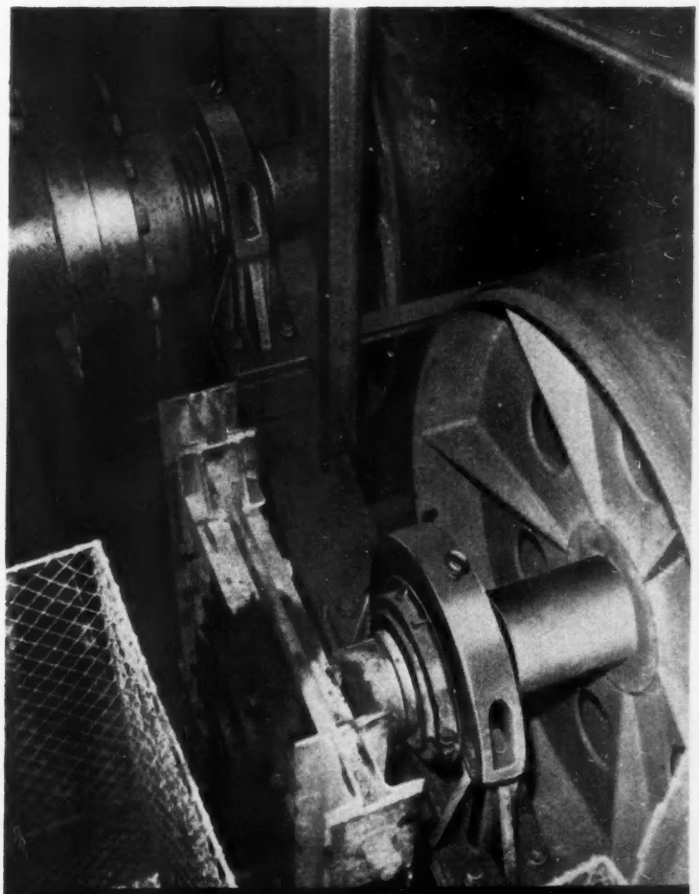

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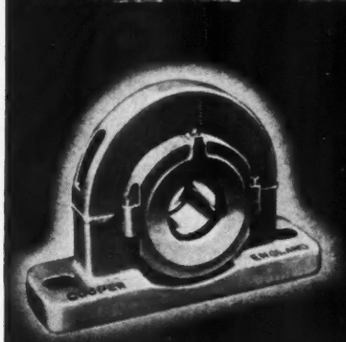

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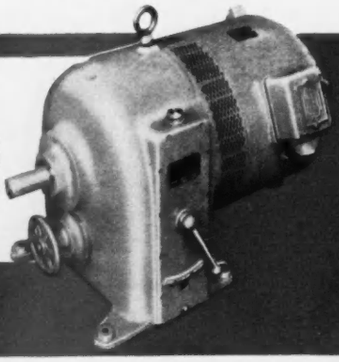

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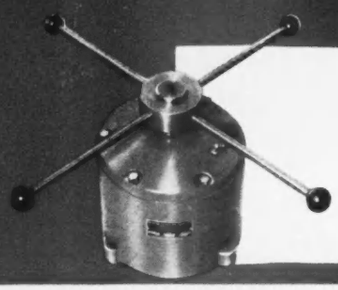

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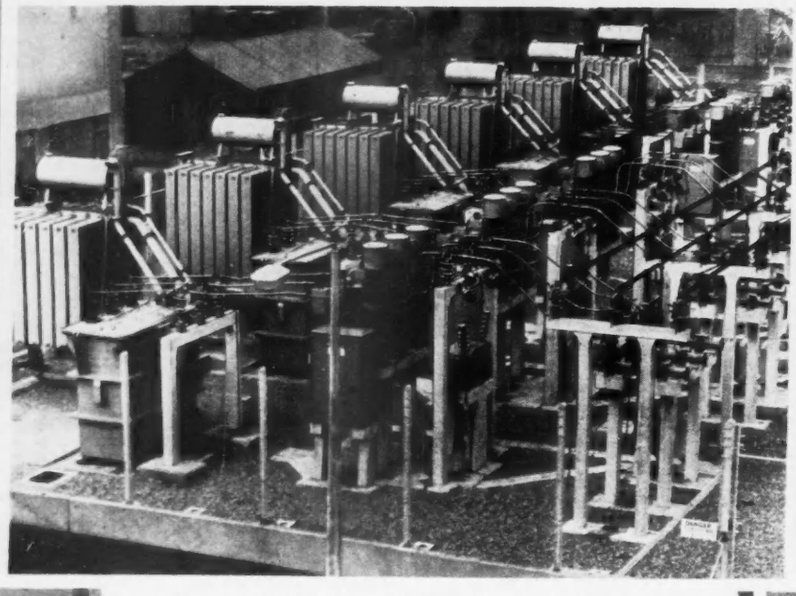

A view of the installation at Rolls-Royce Limited, Sinfin, Derby.

Six 15 MVA 33/11 kV 3 Phase 50 cycles 'ON' Ferranti Transformers have been installed at Rolls-Royce Limited, Derby for the purpose of supplying power to the Aero Engine High Altitude Test Facility (Consulting Engineers, McLellan & Partners in association with Merz and McLellan).

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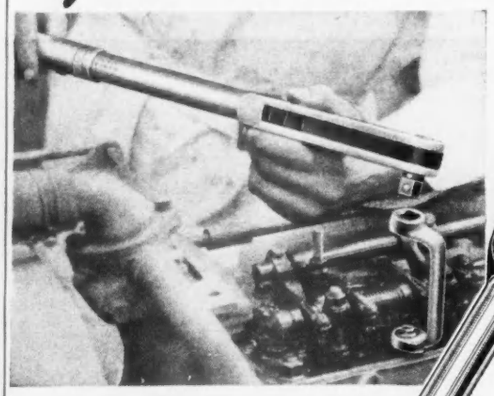

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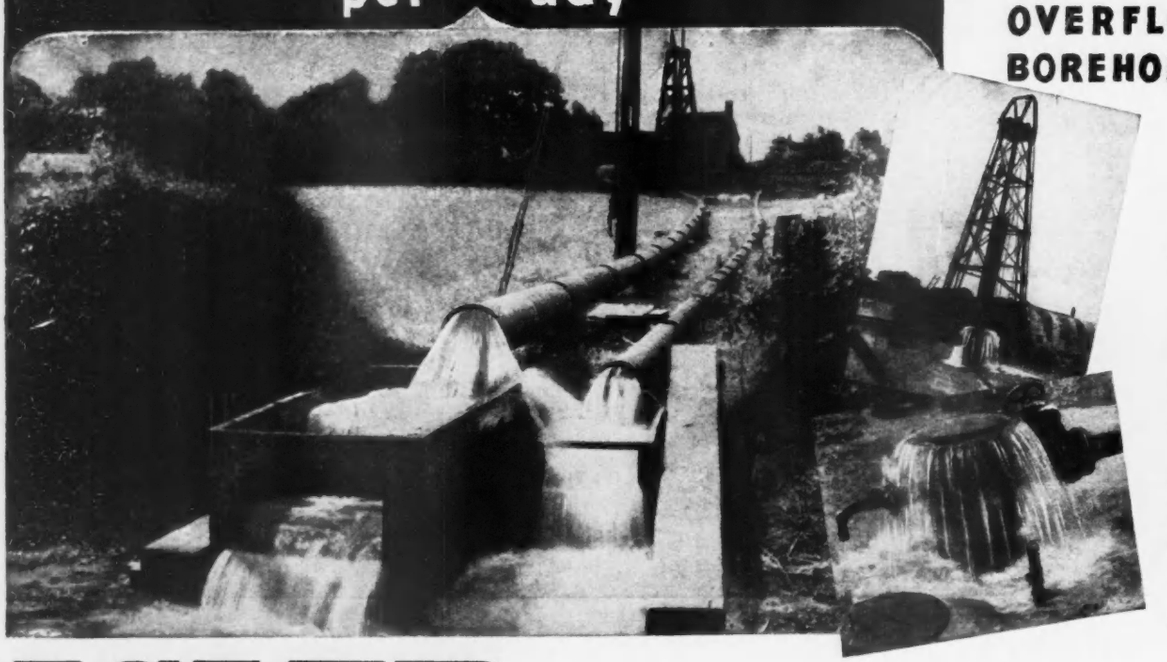

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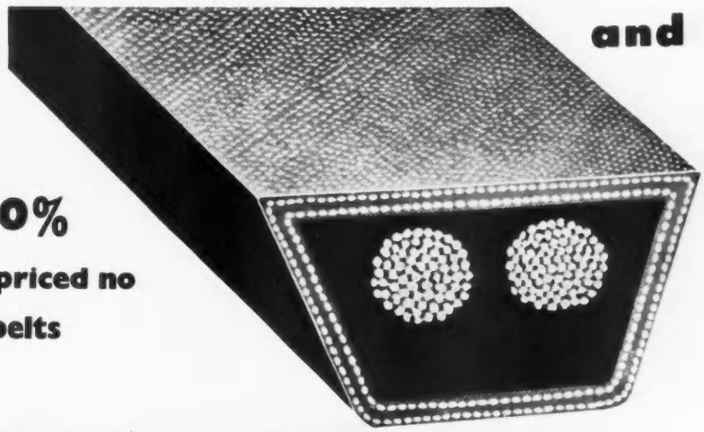
between this  and any other V-belt

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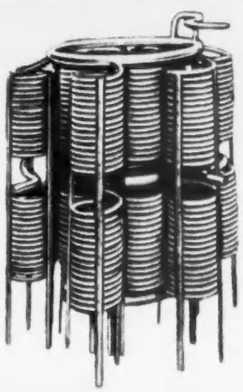

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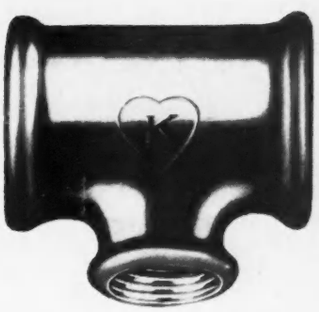

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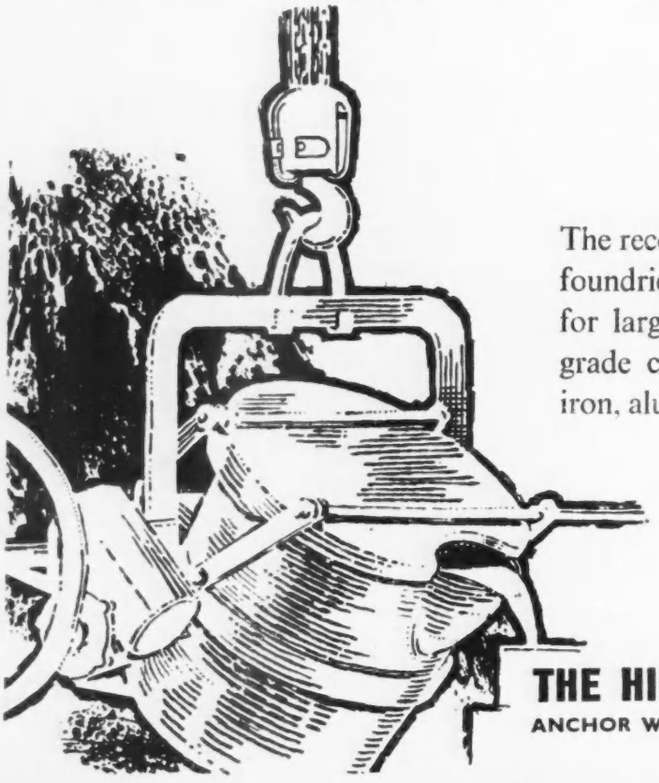

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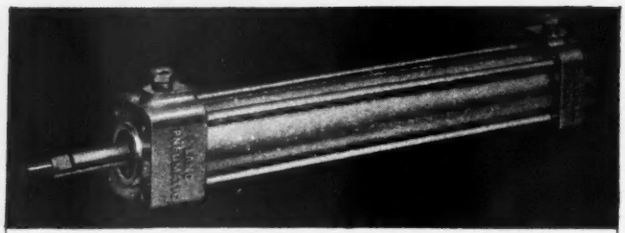
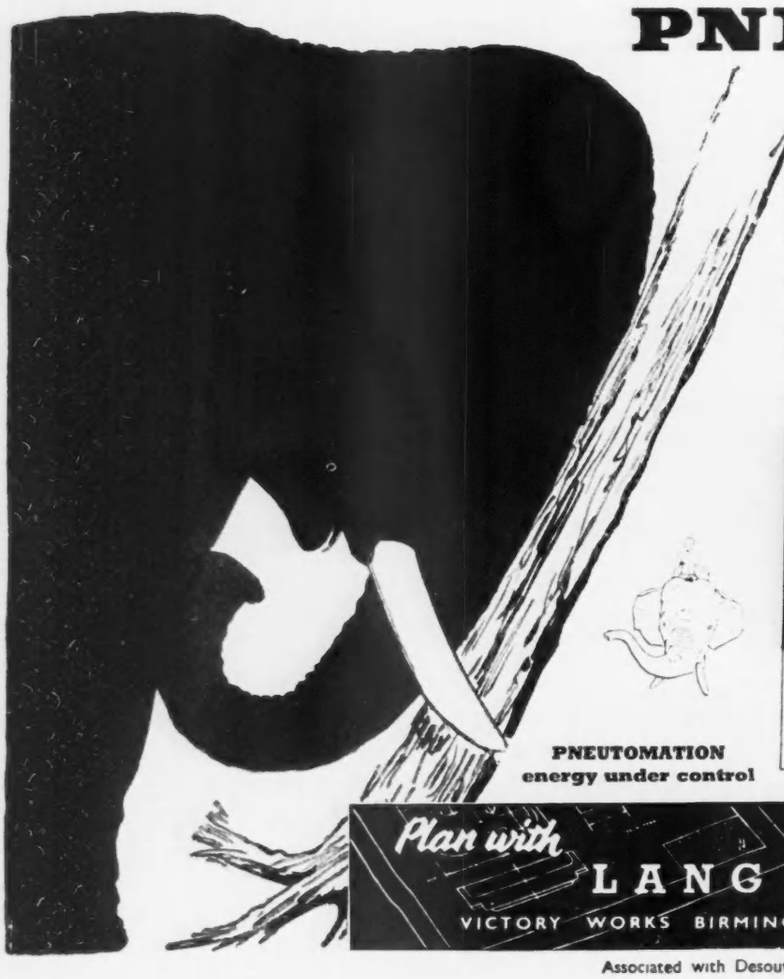


The 'Pneulang' basic cylinder unit, just one of the 264 cylinders available 'off-the-shelf'. The range of **PNEUTOMATION** equipment also includes many types of manual and automatic valves, lubricators, air flow regulators, pipes and fittings, etc.



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P1652

Electrical Aids in Industry *Data Sheet* **No. 4**

Resistance Heating-1

In this form of heating, the heat is produced by passing an electric current through a high resistance conductor which is termed the " heating element ".

The heat is transferred from the heating element to the work by convection, radiation or conduction, or by a combination of any, or all of these. When it is a question of radiation or convection, the element can be a bare wire or strip of suitable material, provided it is adequately supported on electrical insulation capable of withstanding the temperature.

When there is to be contact between the work and the element, heat being transferred to the work by conduction, the wire or strip must be surrounded by suitable insulating material and enclosed in a protective sheath.

In the majority of cases, the wire or strip forming the heating element is made of a nickel-chromium alloy which has a high electrical resistance and can be safely used in air at temperatures of up to 1050°C., or in a suitable atmosphere, of up to 1150°C. Other element materials are available for use at higher temperatures.

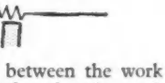
Sheathed elements, essential for contact heating but also used widely for convection and radiation heating because of the convenience afforded by the mechanical strength of the sheath, usually metallic, and by their "built-in" electrical insulation, cannot be used at temperatures as high as the bare wire or strip. This is because the wire, being embedded in insulation, is always at a higher temperature than the sheath, and to keep the wire temperature down to a safe figure the sheath temperature is usually limited to a maximum of around 800°C.

Automatic temperature control of resistance heating elements within narrow limits is easily effected, but if manual control only is desired, devices are available which enable the heat output of the elements to be controlled precisely at a required level. As with all electrical methods, a time switch may be included in the control circuit for automatically switching on or off at predetermined times, and this can enable, for example, an electric oven to be fully up to working temperature by the time the working day starts. Since there are no combustion products from the heaters, there is no need to build flues or special ventilating arrangements which also carry away useful heat.

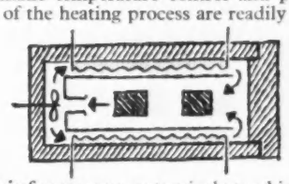
Electric resistance heating may profitably be put to many diverse uses; two of these are described briefly below, others will be listed in a subsequent data sheet.

Furnace Heating

Electric resistance furnaces can be divided into two main categories, batch type and continuous. In most cases, the heating elements are of nickel-chromium alloy, for furnace temperatures up to around 1050°C., but higher temperatures, up to nearly 3000°C., can be obtained by using other metals or alloys, or in some cases non-metallic elements. A protective atmosphere is desirable to prolong the life of some of these higher-temperature elements. For all temperatures, electric resistance furnaces can be constructed so that the heating process takes place in a controlled atmosphere if this is dictated by the composition or heat requirements of the work charge. In some furnaces, fans are used to circulate the air or special atmosphere over the charge, thereby giving increased heating rates and a uniform temperature over the whole charge.



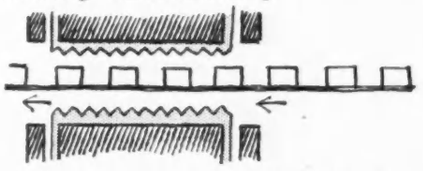
Automatic temperature control and programme control of the heating process are readily effected.



Electric furnaces are extensively used in industry, for example in the general heat treatment of metals, in the glass and ceramics industries, for brazing and sintering, and for many other applications requiring temperatures above 500°C.

Oven Heating

There are two basic forms of heat transfer used in electric resistance ovens: convection and radiation. The latter is dealt with in a separate data sheet under the heading " Infra-Red Heating "



Convection ovens may again be of the batch or continuous type. In either case, the charge is heated mainly by the movement of hot air, which is sometimes assisted, as in furnaces, by fans to give a rapid and uniform temperature rise. Ovens are normally designed for temperatures of up to about 500°C., and the heating elements are invariably of nickel-chromium or nickel-chromium-iron alloy.

Ventilation, when required, can be provided and regulated entirely to suit the heating process. Temperatures and times are readily controlled. A vacuum can be maintained in suitably designed ovens to assist in the extraction of moisture and solvent.

Convection ovens are extensively used for drying, baking and stoving operations, and for a host of other processes requiring a low or medium temperature.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, W.C.2.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available—"Induction and Dielectric Heating" is an example; "Resistance Heating" is another.

E.D.A. also have available on free loan a series of films on the industrial use of electricity. Ask for a catalogue.

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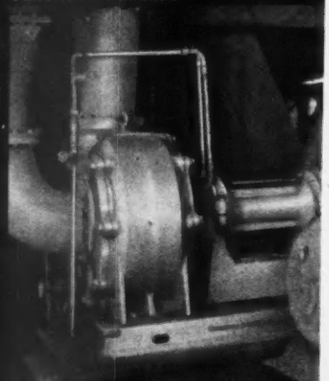

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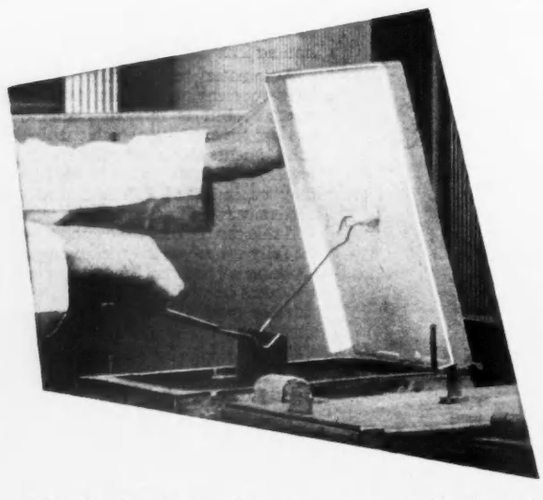

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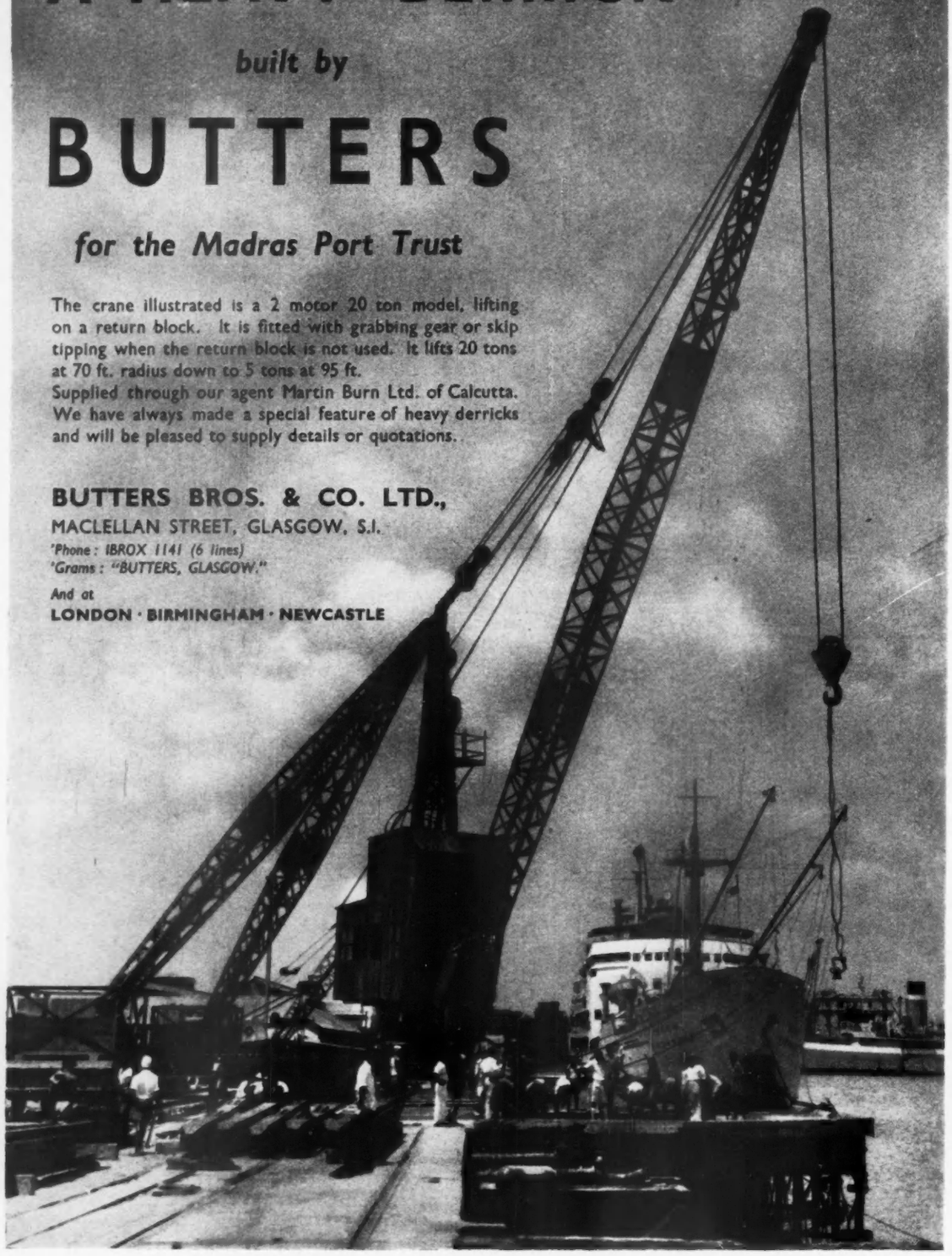

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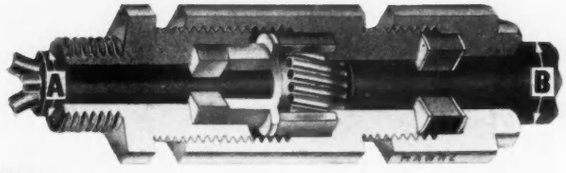
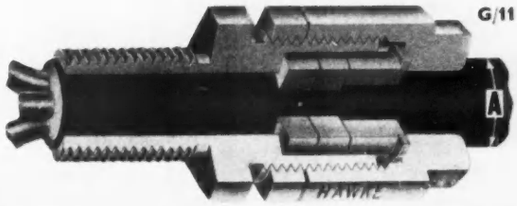


8/G3



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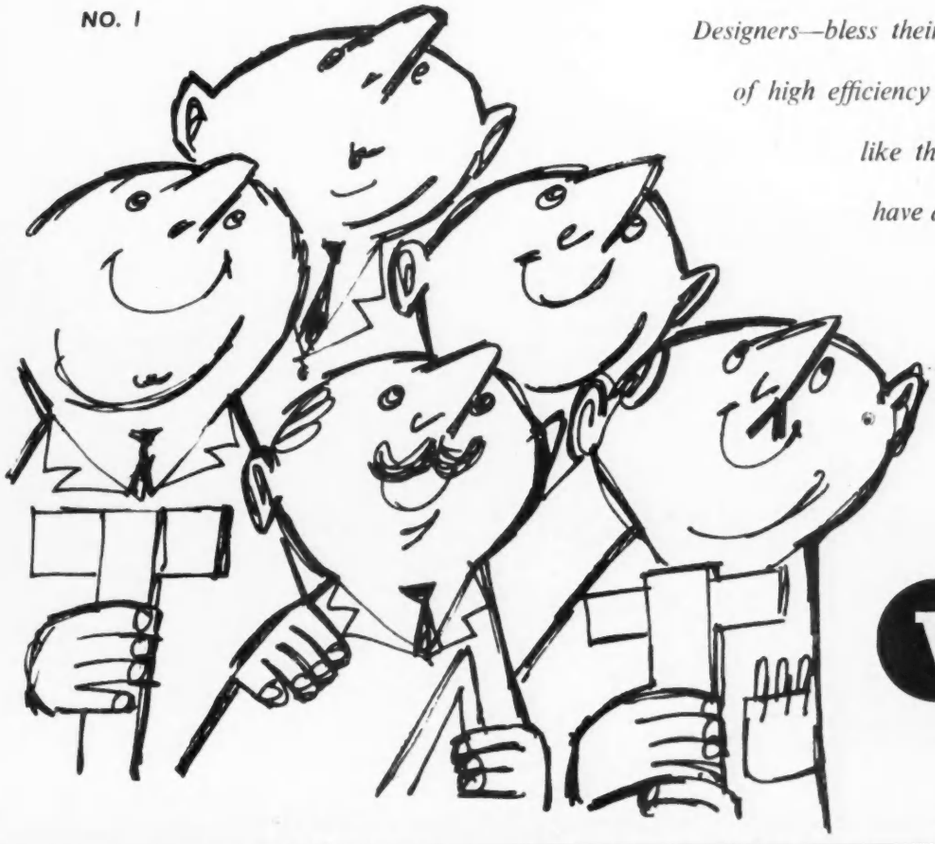

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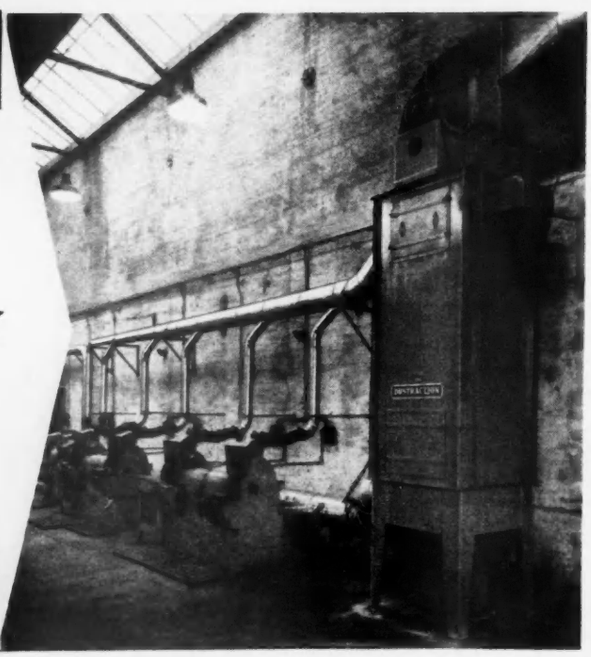

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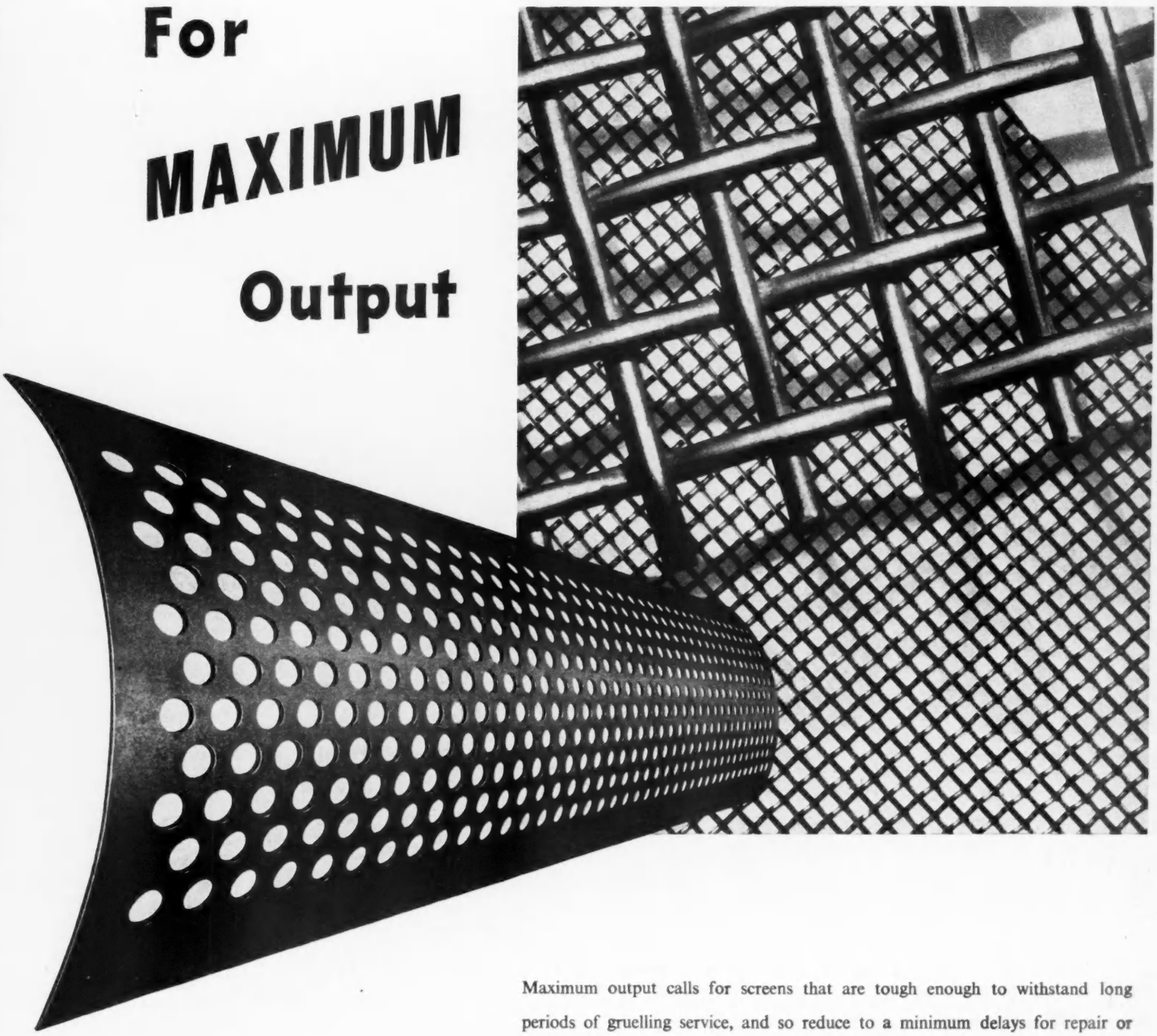

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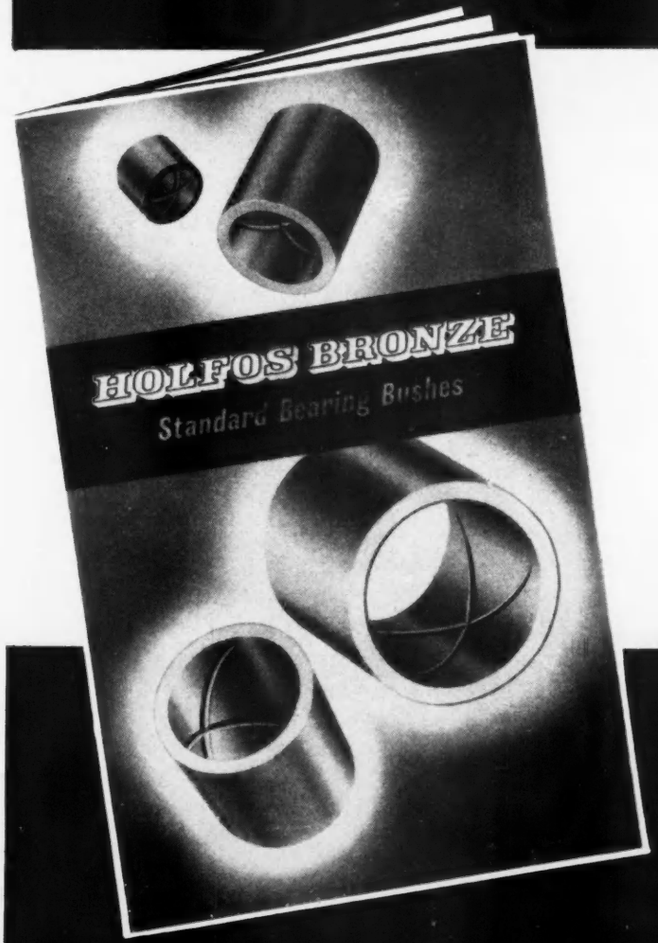

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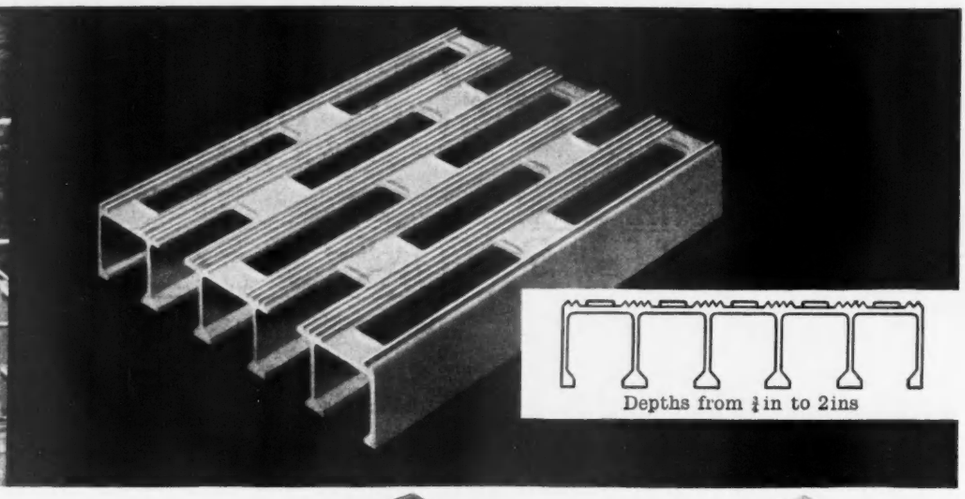

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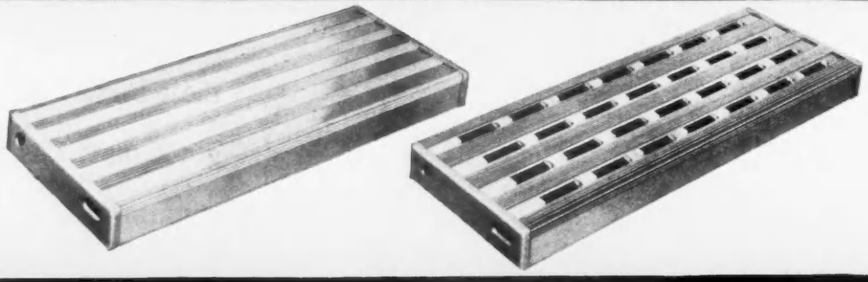

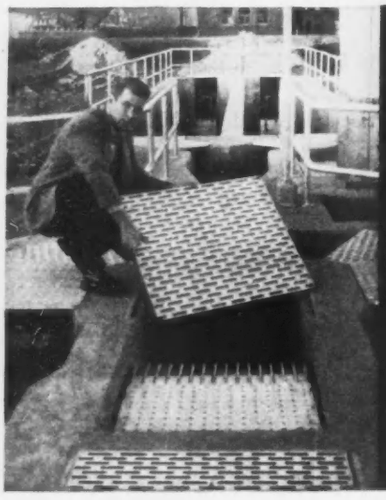

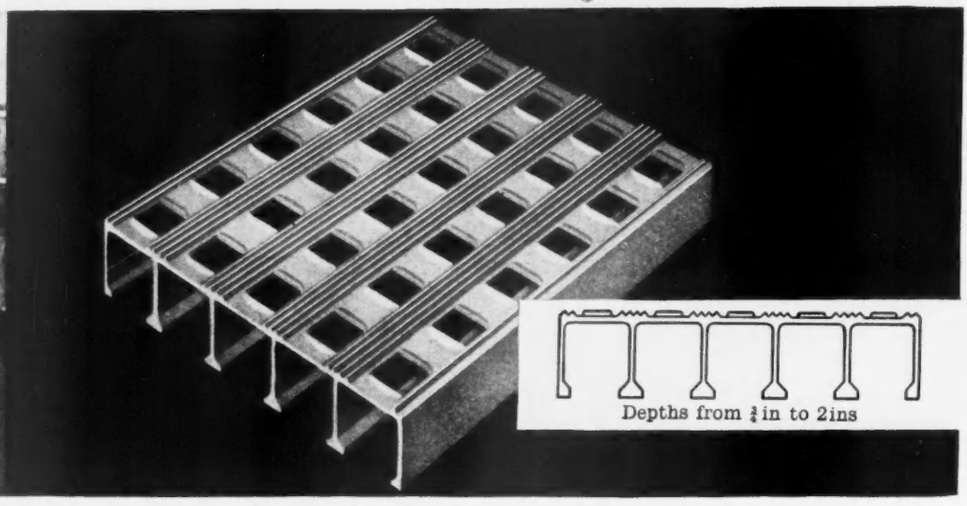

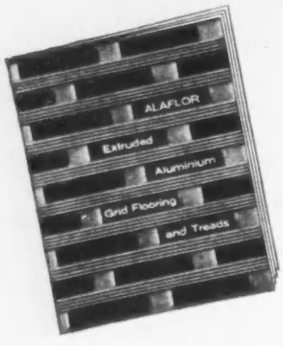

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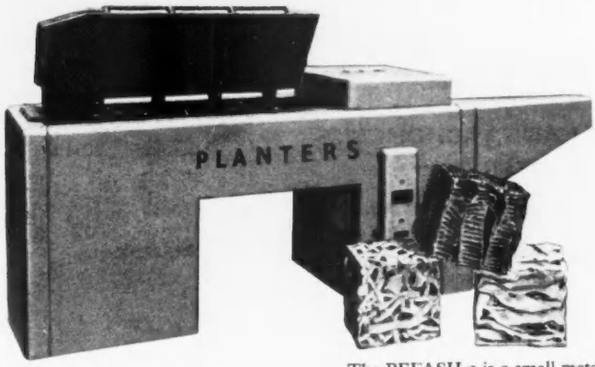

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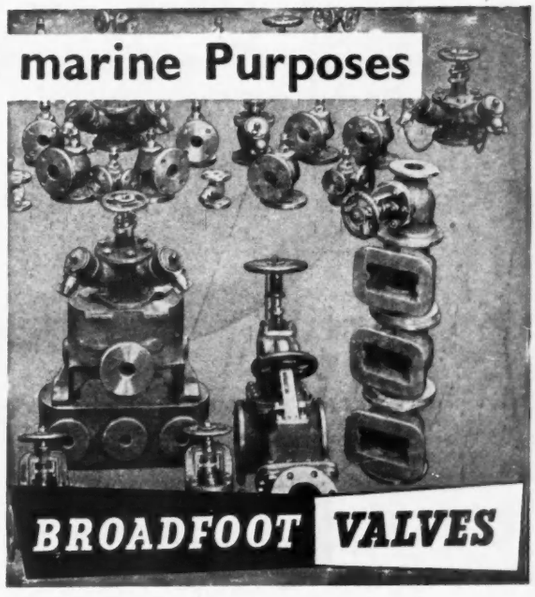

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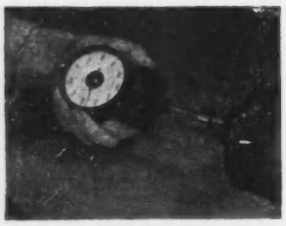

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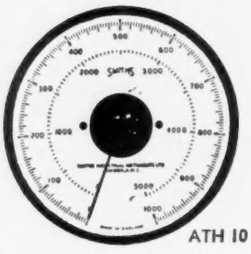

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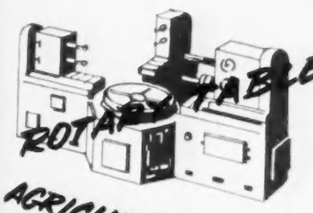

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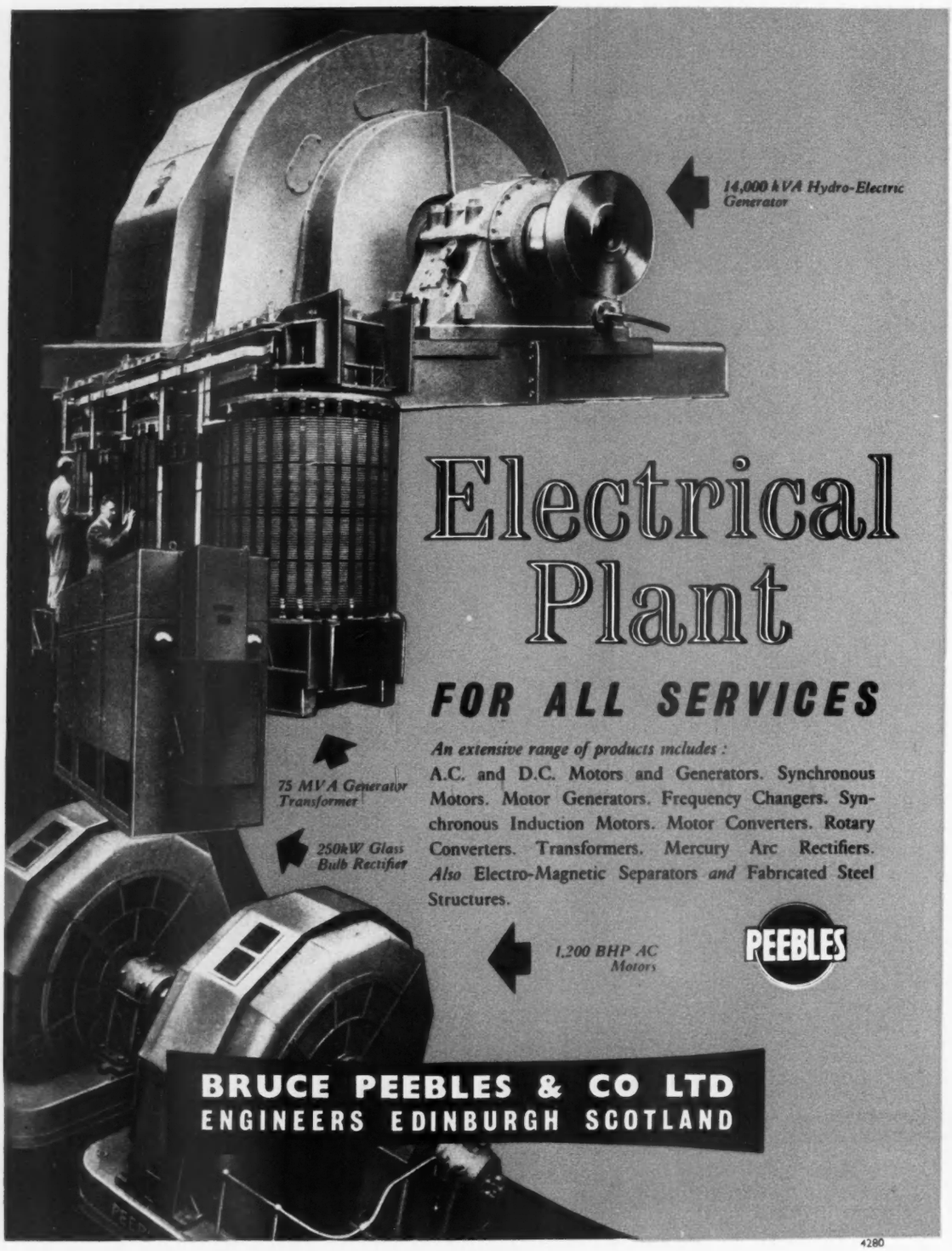
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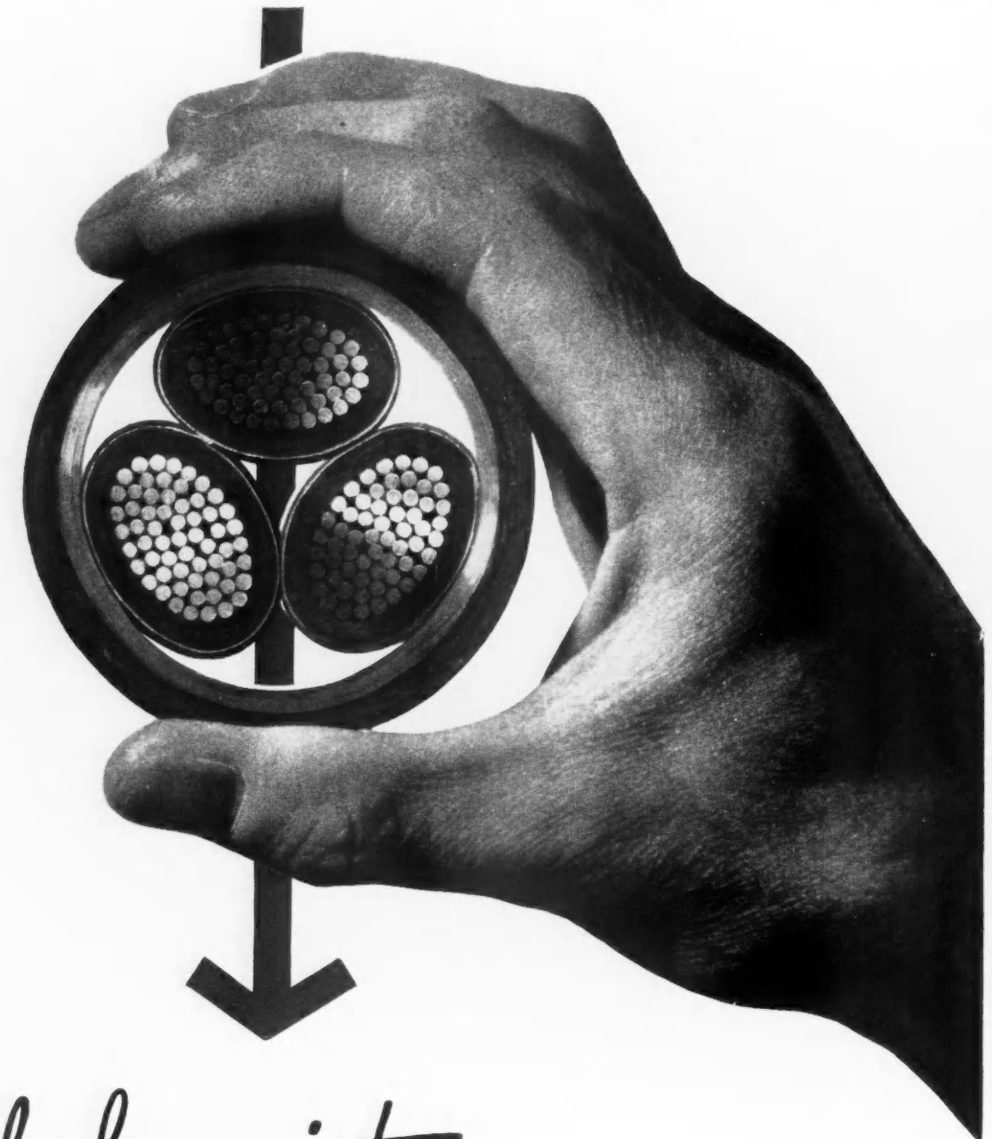

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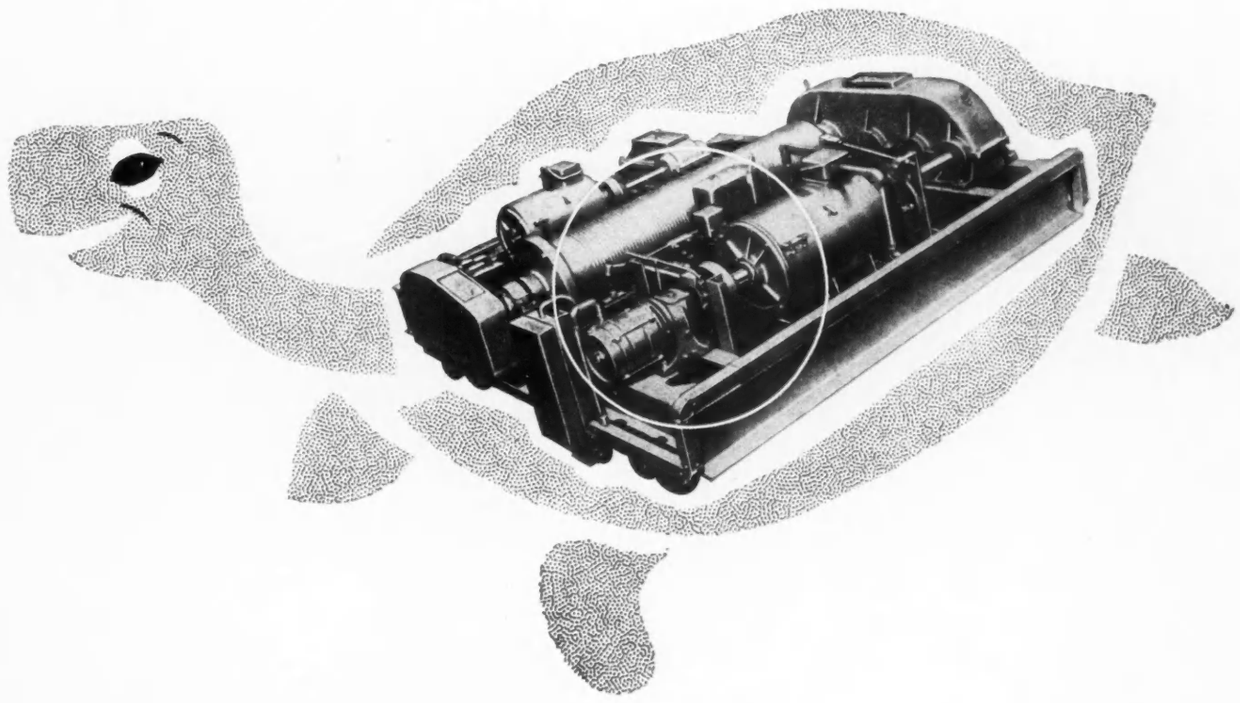

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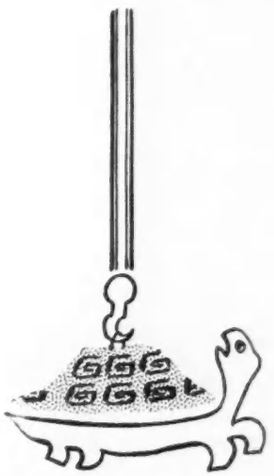

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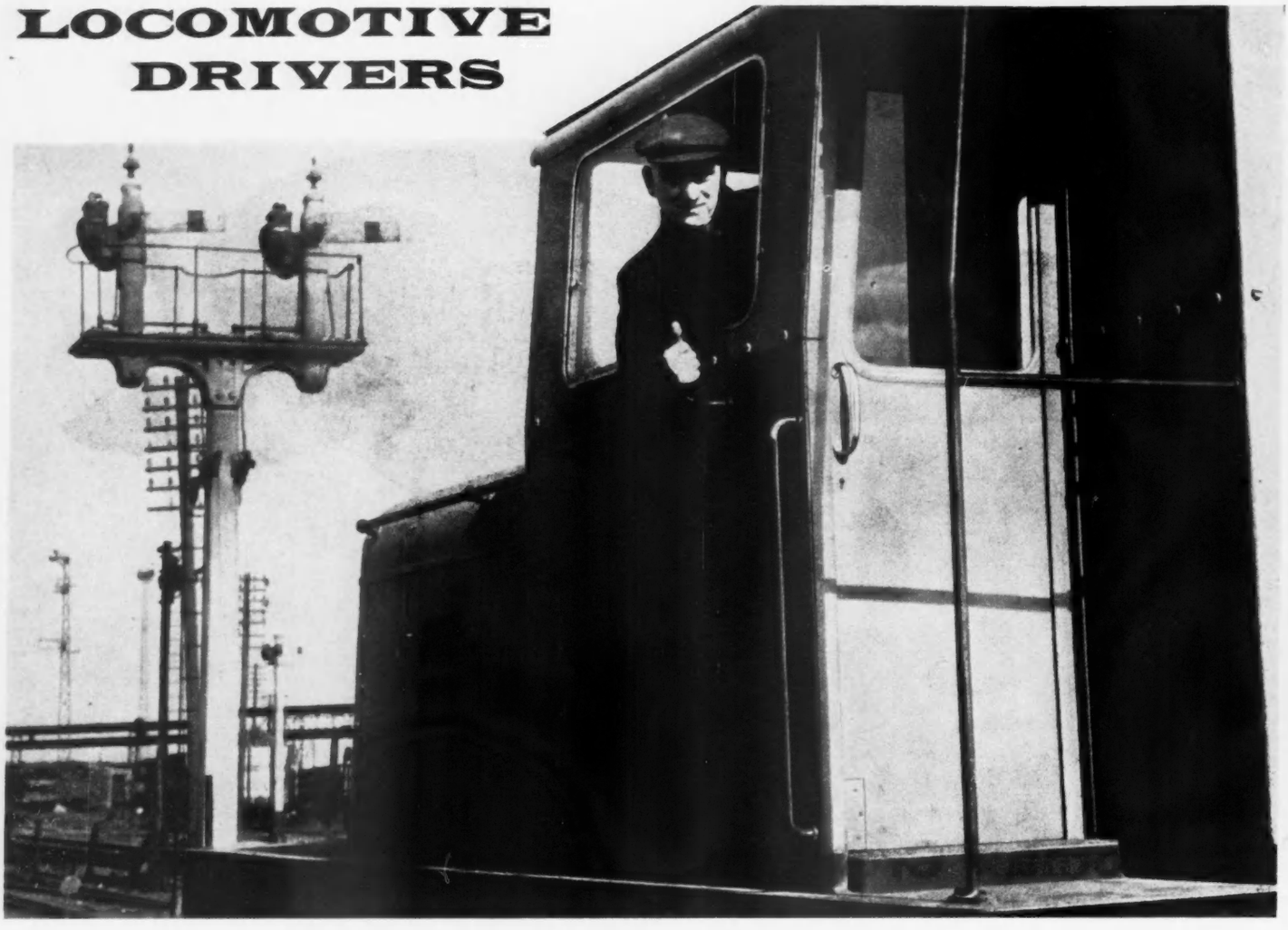

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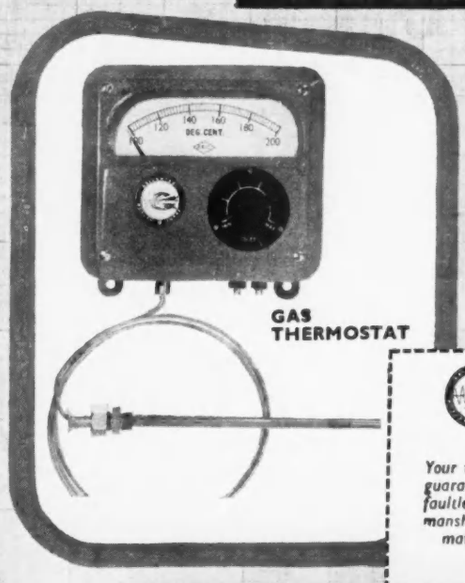

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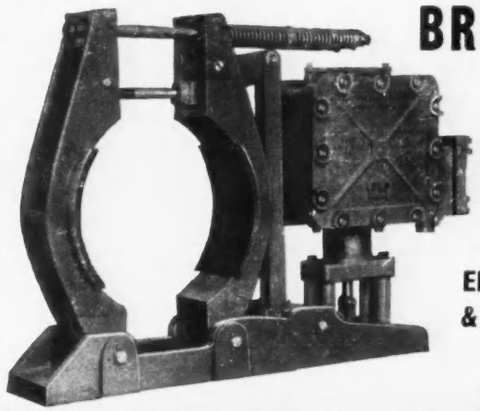

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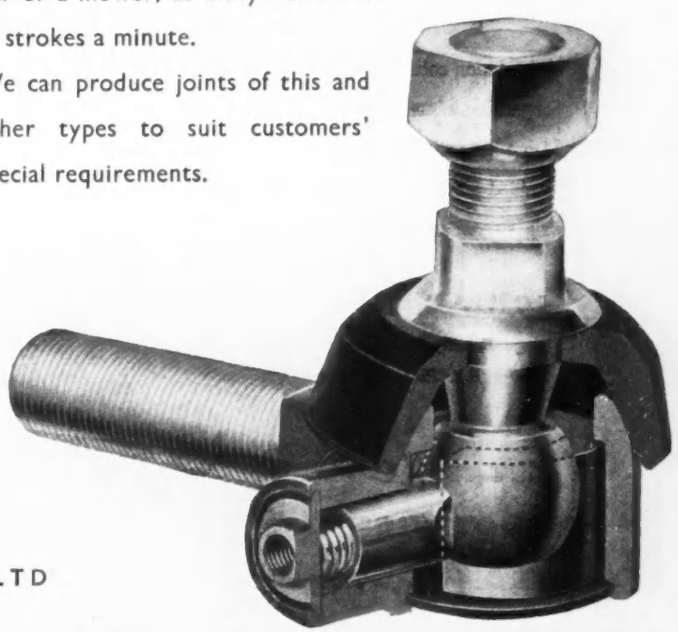

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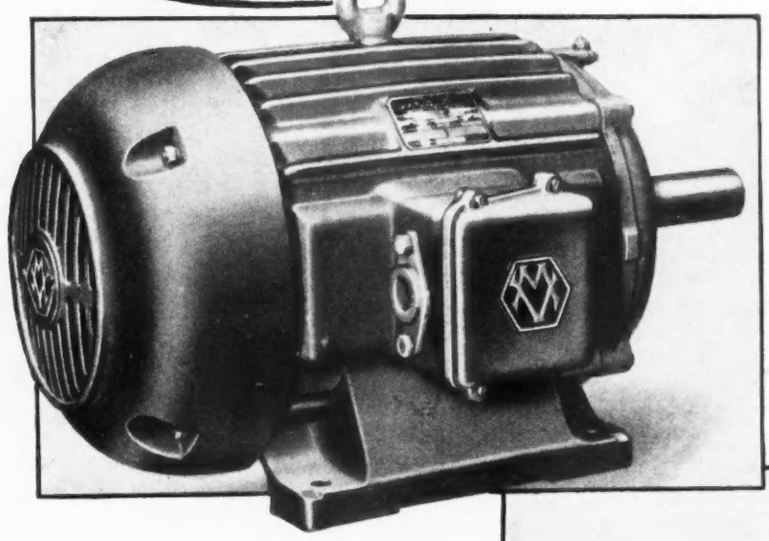

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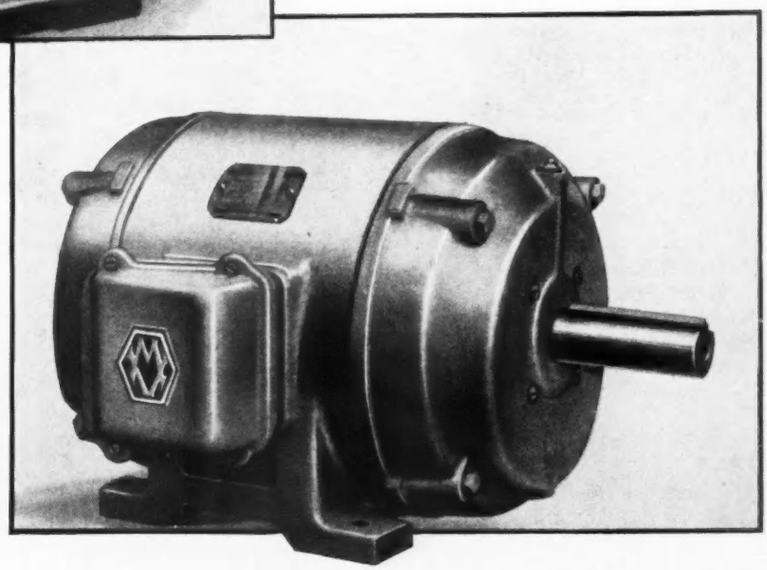

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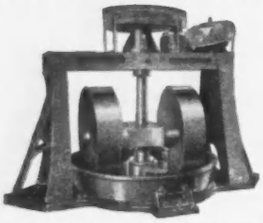

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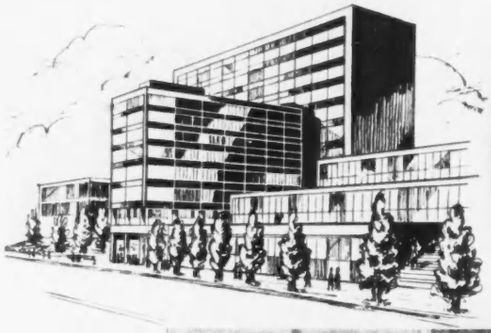

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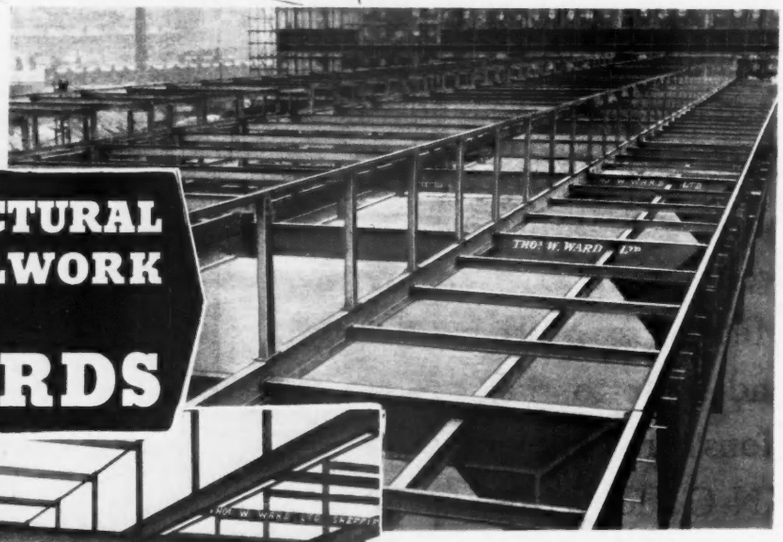

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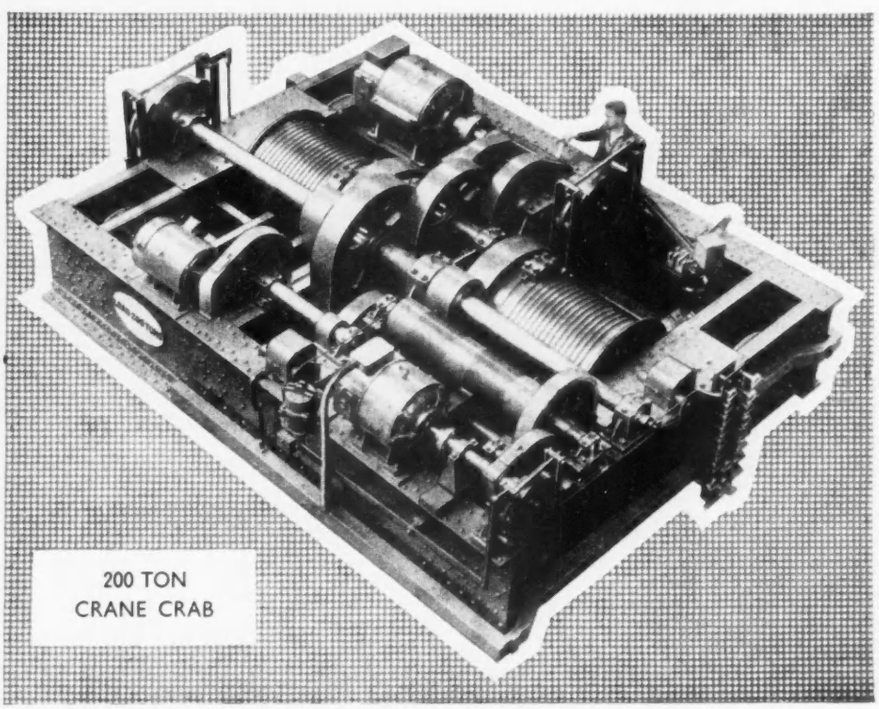

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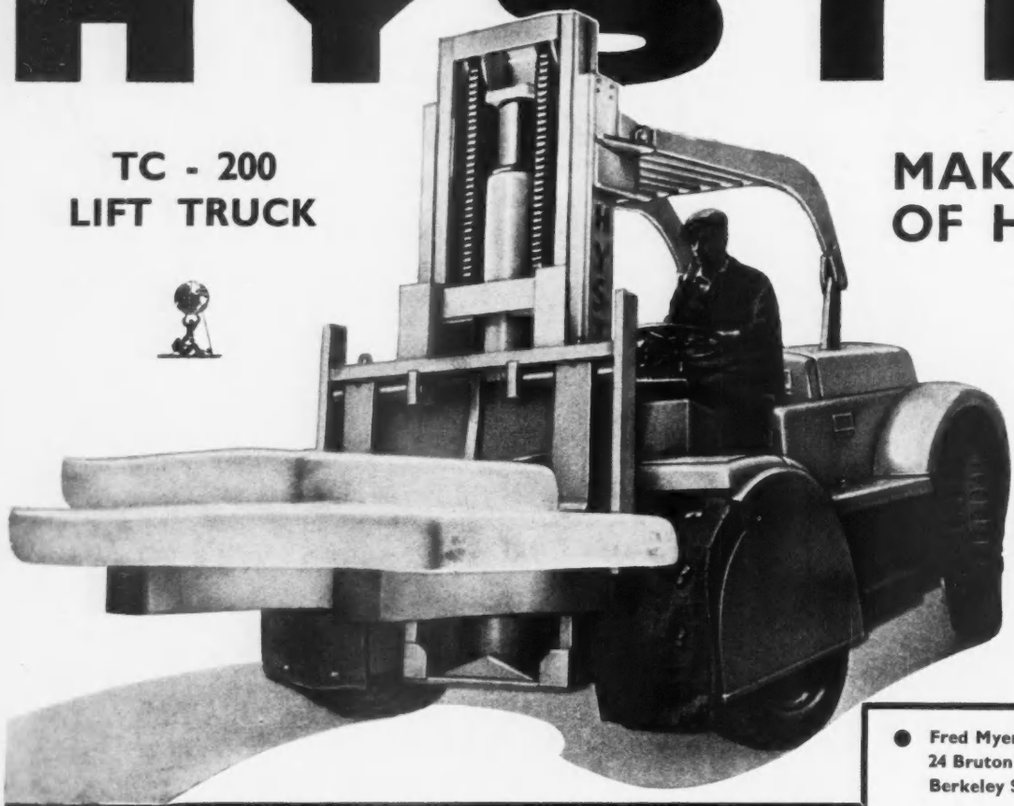

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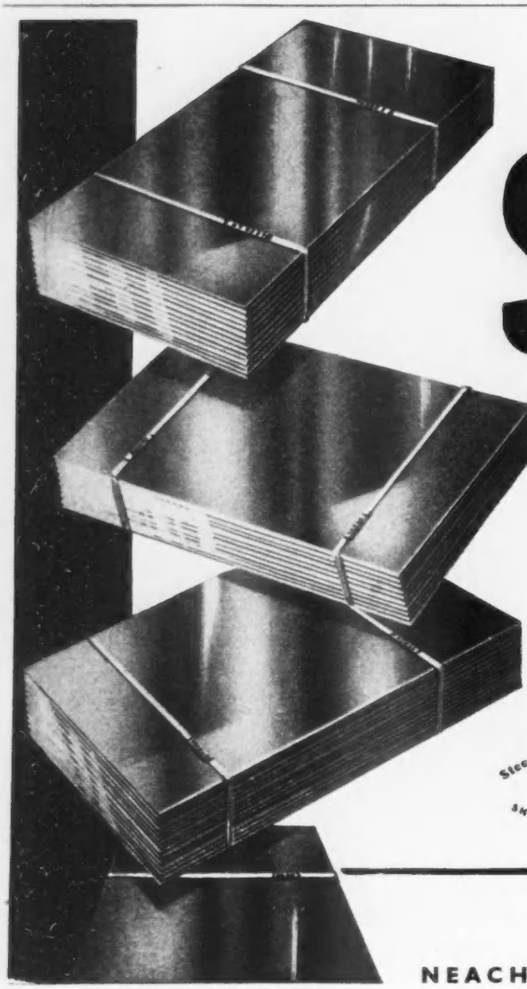

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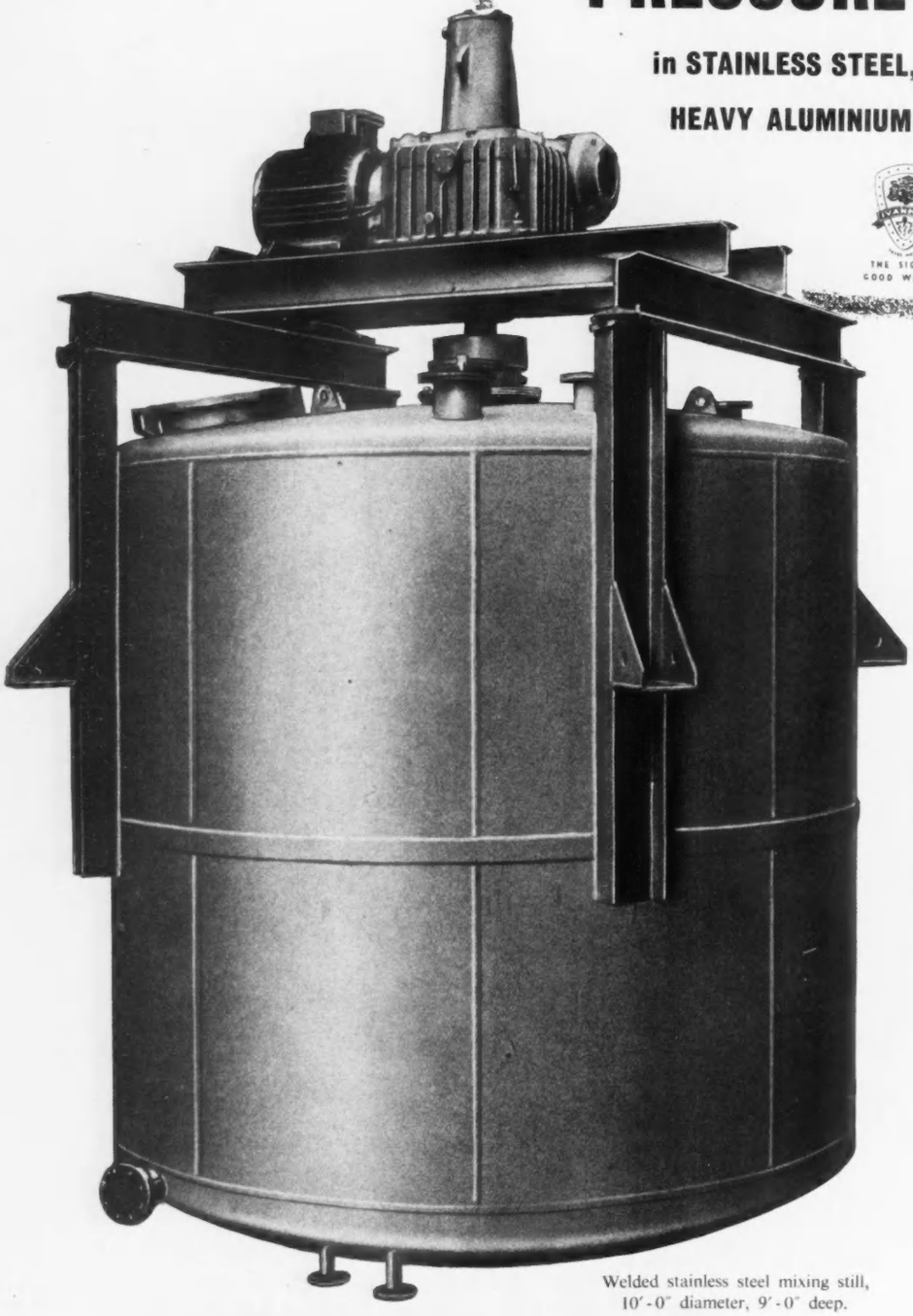

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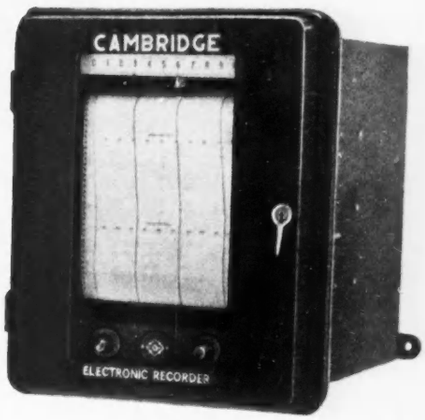

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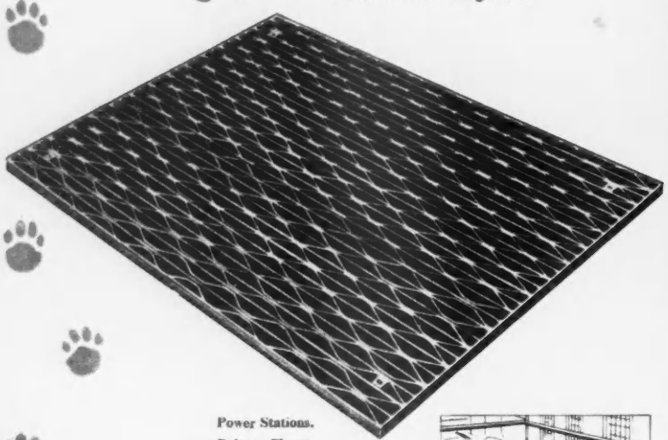

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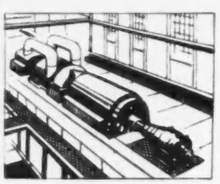

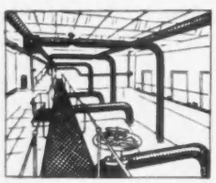

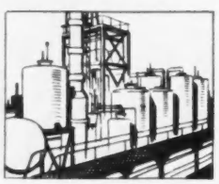

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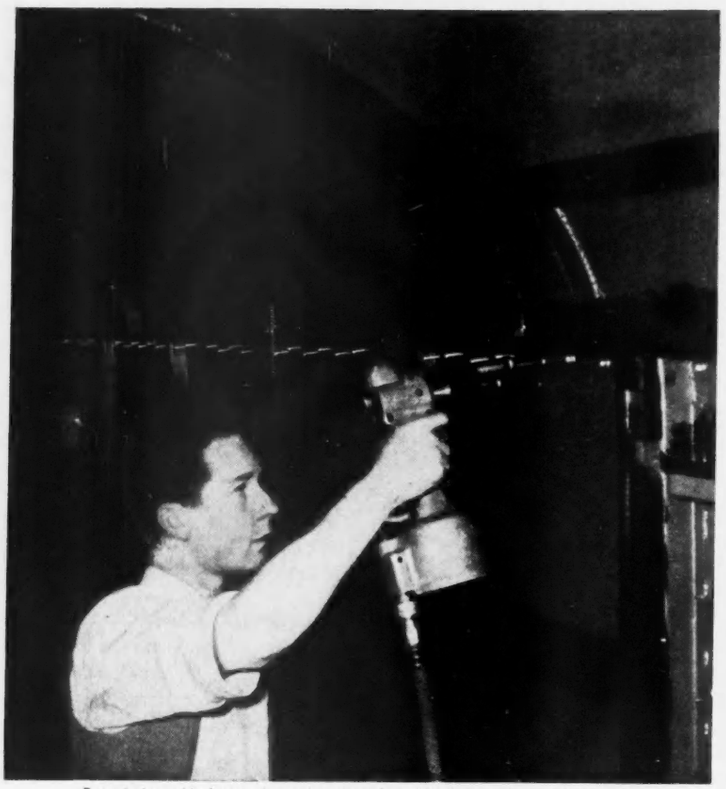
Automatic high-speed fastening system outdates nuts, bolts and rivets!

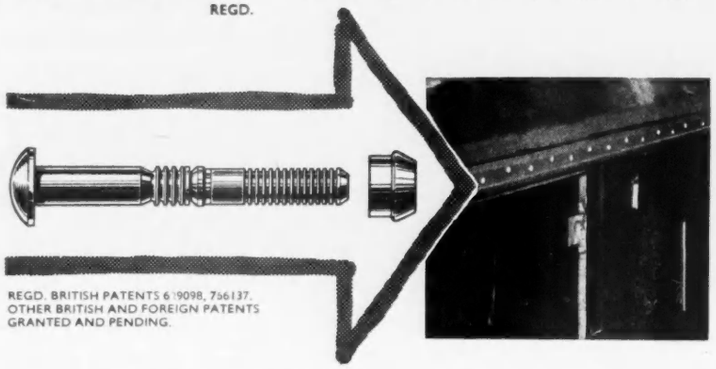


Extensively used in America in a wide variety of metal fabricating industries, British-made Lockbolts are here shown being used to fix gutter extrusion on a diesel car for British Railways.

AVDEL LOCKBOLTS cut assembly costs—drastically! With this revolutionary high-speed system, automatic, vibration-proof bolting of great strength is achieved *without* the use of skilled labour, at speeds up to 30 bolts per minute. Available in high-strength aluminium alloys and steel, Avdel Lockbolts provide positive, mechanical self locking with high clench and sealing qualities. Considerable shear/tension strength and fatigue resistance are important advantages, and what's more, because bolt driving is completely automatic, each fastening is a 'quality job' *regardless* of the operator's skill.

AVDEL LOCKBOLTS

REGD.



REGD. BRITISH PATENTS 619098, 756137.
OTHER BRITISH AND FOREIGN PATENTS GRANTED AND PENDING.

AVIATION DEVELOPMENTS LIMITED
229/231 HIGH HOLBORN · LONDON W.C.1 · *Tel: CHAncery 8601*
AD20

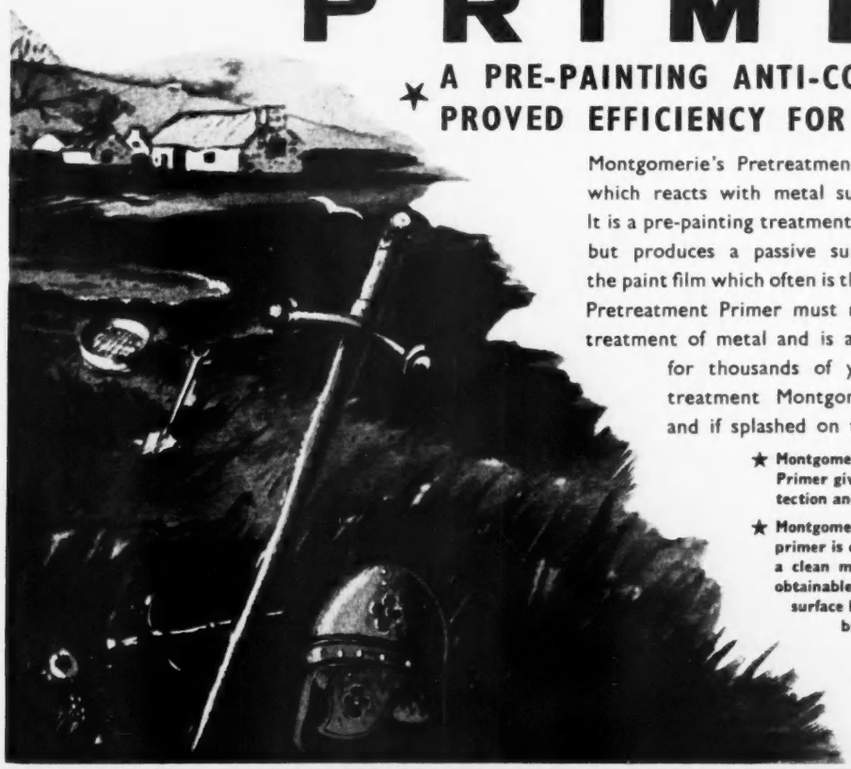
TANNIN protected them through centuries from corrosion . .

No doubt you have watched with interest the T.V. Programme 'Animal, Vegetable and Mineral' and wondered how metal objects such as Armour, Swords, Nails, etc., could have possibly survived the ravages of corrosion through thousands of years.

When metal objects are found in good preservation they are nearly always embedded in leather or peat deposits.

In their researches to explain this, Chemists have isolated a material called **TANNIN** which, when applied to metal, gives excellent protection against corrosion and forms the perfect basis for normal painting systems.

MONTGOMERIE'S PRETREATMENT PRIMER



★ **A PRE-PAINTING ANTI-CORROSIVE TREATMENT OF PROVED EFFICIENCY FOR ALL METAL STRUCTURES**

Montgomerie's Pretreatment Primer is an aqueous solution of Tannin which reacts with metal surfaces producing a film of Ferric Tannate. It is a pre-painting treatment and is not intended to replace Metal Primers but produces a passive surface, preventing corrosion starting under the paint film which often is the cause of many paint failures. Montgomerie's Pretreatment Primer must not be compared with the usual Phosphate treatment of metal and is a "natural" process which has proved itself for thousands of years. Unlike other types of pre-painting treatment Montgomerie's Pretreatment Primer is non-toxic and if splashed on the skin has no injurious effects.

★ **Montgomerie's Pretreatment Primer gives maximum protection and adhesion.**

★ **Montgomerie's Pretreatment primer is effective even when a clean metal surface is unobtainable, providing the surface has been well wire-brushed and scraped.**

★ **Montgomerie's Pretreatment Primer being an aqueous solution, can be applied on wet surfaces.**

★ **Montgomerie's Pretreatment Primer has a covering capacity of approximately 1,000 sq. ft. per gallon.**

★ **Montgomerie's Pretreatment Primer, due to its outstanding anti-corrosive properties, allows painting to be delayed if necessary for up to 10 days without deterioration of the surface.**

montgomerie stobo & co. ltd.

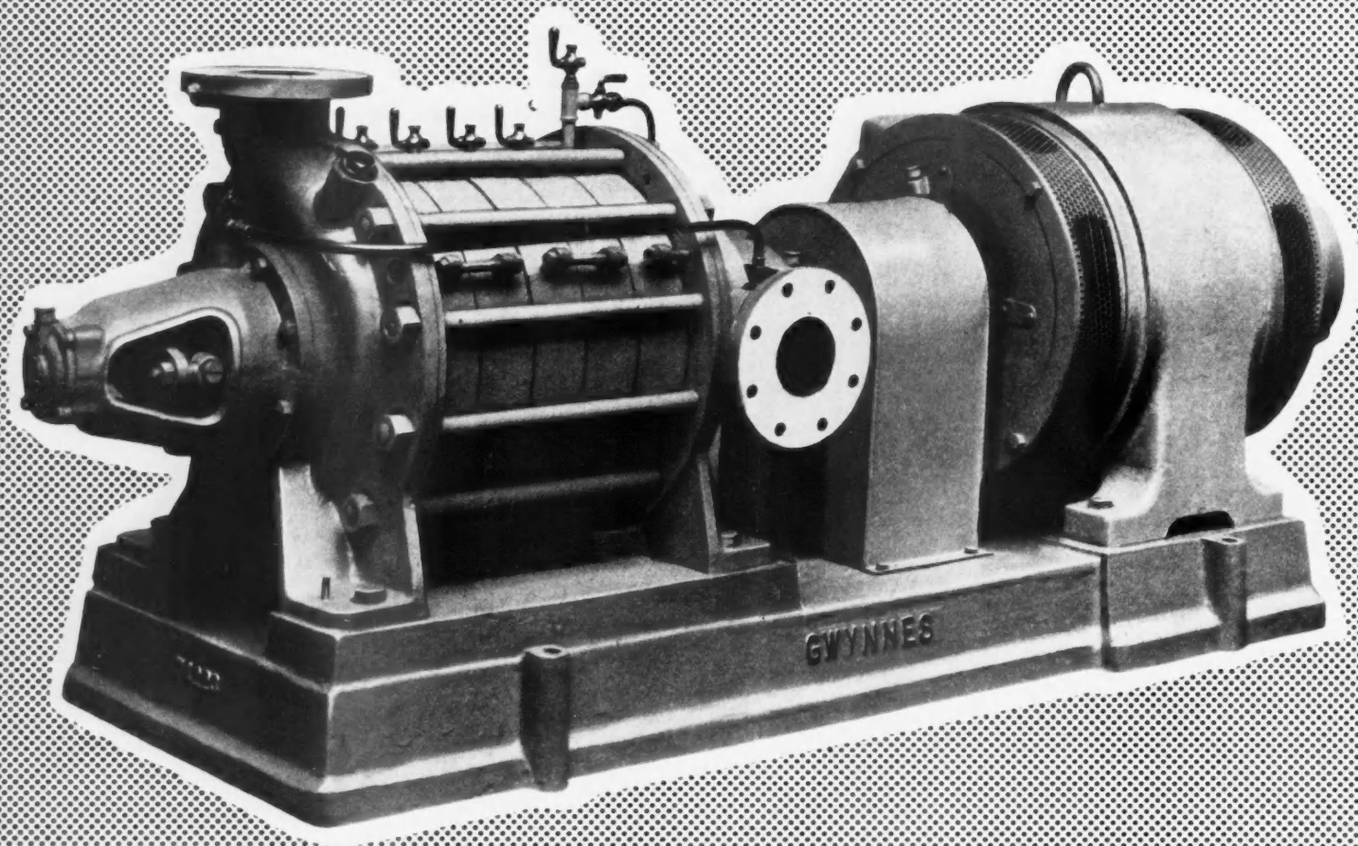
Deeside, Saltney, Nr. Chester.
Telephone Chester 23128 (3 lines)
Telegrams 'Turpentine' Chester.

136/154 Stranmillis Road, Belfast.
Telephone Belfast 67978.
Telegrams 'Turpentine' Belfast.

52-72 Rogart Street, Glasgow, S.E.
Telephone Bridgeton 1005/6/7.
Telegrams 'Turpentine' Glasgow.

Also at Slough

Gwynnes STANDARD Multi-stage Pressure pumps



Gwynnes standard multi-stage turbine pressure pumps are from 1½" size to 9". The stages vary between two and eight to suit the head requirements. Larger pumps or pumps with more stages are supplied to meet specific requirements.

GWYNNES PUMPS LTD
HAMMERSMITH · LONDON W.6

GWYNNES PUMPS

Telephone · RIVerside 3682 (4 lines)
Telegrams · Gwynne · Hammer · London

CLASSIFIED ADVERTISEMENTS

AGENCIES · DIRECTORS · PARTNERSHIPS · SITUATIONS VACANT · EDUCATIONAL PATENTS · BUSINESS OPPORTUNITIES · MISCELLANEOUS · PUBLIC APPOINTMENTS BUSINESSES and PREMISES · TENDERS

Lineage Rate. 4/- per line of approximately 6 words. Minimum 16/-

Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch.
There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

AUCTION SALES · FOR HIRE · MACHINERY, etc., WANTED · SITUATIONS WANTED DRAWING AND DESIGN SERVICES · FOR SALE · SUB-CONTRACTING

Lineage Rate. 3/6 per line of approximately 6 words. Minimum 14/-.

Inch Rate. 42/- per single column inch and *pro rata*. 12 lines to 1 inch.
There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £22. ½-page £41 10s. Full page £78.

Series Discounts. For advertisements 1 inch and upwards. 6 insertions 5%. 13 insertions 10%. 26 insertions 15%.

Run-on and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

NORWICH CITY COLLEGE AND ART SCHOOL

IPSWICH ROAD, NORWICH

Principal: FRANK BRIERS, B.Sc., D.Phil. (Oxon), F.R.I.C.

APPOINTMENTS

Wanted for 1st January, 1959, or as soon as possible thereafter:—

(a) LECTURER IN ELECTRICAL ENGINEERING, for teaching duties in Sandwich Diploma, Ordinary and Higher National Certificate and City and Guilds Electrical courses.

Applicants should possess University Degree, A.M.I.E.E., or equivalent, and have had teaching and suitable industrial experience.

Salary: £1200 by £30 to £1350.

(b) TEACHER (Grade A) IN MECHANICAL ENGINEERING, for teaching duties mainly in Ordinary National Certificate and City and Guilds courses. There may be an opportunity for some teaching at a more advanced level.

Applicants must possess the Higher National Certificate in Mechanical Engineering or the Graduateship of the Institution of Mechanical Engineers, and have had some industrial experience.

Salary: Grade A, Burnham Technical Scale (£475 by £25 to £900, plus appropriate allowances).

Application forms, obtainable from the Director of Education, City Hall, Norwich, on receipt of a stamped, addressed envelope, should be returned to the Principal as soon as possible. Previous applicants will be reconsidered automatically. E9222

ROYAL TECHNICAL COLLEGE, SALFORD

DEPARTMENT OF MECHANICAL ENGINEERING

LECTURER AND SENIOR LECTURER

Applications are invited for a number of posts of LECTURER and SENIOR LECTURER in the Department of Mechanical Engineering.

This rapidly expanding Department of the College of Advanced Technology is developing exceptionally good conditions for teaching and research work.

Applicants should have an Honours Degree in Engineering, or an equivalent qualification. Importance is attached to professional engineering or research experience. Teaching experience, though an advantage, is not essential. Staff are encouraged to develop their own interests and will be given assistance to carry out research and develop contacts with industry or other organisations.

The salary offered is in accordance with the Burnham Technical Report 1956. Senior Lecturer: £1350–£1550 (men); £1080–£1240 plus 4/7ths differential (women). Lecturer: £1200–£1350 (men); £960–£1080 plus 4/7ths differential (women). The starting point in each grade will depend upon the experience and qualifications of the candidate.

Forms of application, together with further particulars, may be obtained from the Registrar, Royal Technical College, Salford, 5, to whom they should be returned as soon as possible.

R. RIBBLESDALE THORNTON,
E9201 Clerk to the Governors.

NORTH RIDING EDUCATION COMMITTEE

SCARBOROUGH TECHNICAL COLLEGE

PRINCIPAL

Applications are invited for the post of PRINCIPAL of this new College, now being built and expected to open in September, 1960. The successful applicant will hold office from September 1, 1959, as Principal of the existing Scarborough Technical Institute. Applicants should preferably be Graduates in Commerce or in Mechanical or Electrical Engineering with appropriate experience in industry and technical education.

The salary scale under the existing Burnham Report is at present £1600 by £50 to £1700 by £35 to £1735. Application forms and further particulars available from me on receipt of stamped, addressed envelope. Completed forms to be returned by 13th December, 1958.

F. BARRACLOUGH.
County Hall,
Northallerton. E9141

PUBLIC APPOINTMENTS

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

INDUSTRIAL GROUP, CHAPELCROSS WORKS, ANNAN, DUMFRIESSHIRE, SCOTLAND

ASSISTANT MANAGER (POWER PLANT)

ASSISTANT MANAGER (POWER PLANT) required by the United Kingdom Atomic Energy Authority, Industrial Group at Chapelcross Works, Annan, Dumfriesshire, Scotland, to be responsible to the Power Manager for the take-over, commissioning and operation of sections of steam and electric plant associated with four nuclear reactors.

A recognised engineering apprenticeship, Corporate Membership of a Senior Engineering Institution, or equivalent, and wide experience of the operation of conventional thermal power plant are essential.

Salary between £1300 and £1740, according to qualifications and experience.

Contributory superannuation.

There is a staff housing scheme.

Send postcard for application form, quoting reference 2748, to Works Secretary at above address.

Closing date: 1st December, 1958. E9167

AIR MINISTRY WORKS

DESIGN BRANCH, LONDON

DESIGNER DRAUGHTSMEN

Air Ministry Works Design Branch requires in London DESIGNER DRAUGHTSMEN for Bulk Petroleum Storage and Pumping Installations experienced in one or more of the following: (a) Storage tank layout and design; (b) Pump house and plant layout; (c) development of pipe line schemes; (d) hydraulic calculations. Technical training to O.N.C. standard required. Salaries up to £1015 p.a. Starting pay dependent on age, qualifications and experience. Long-term possibilities with promotion and pensionable prospects. Five-day week, 3 weeks 3 days leave a year. Normally natural born British subjects.—Write, stating age, qualifications, employment details including type of work done to any Employment Exchange quoting Order No. Borough 105. E9176

WEST KENT MAIN SEWERAGE BOARD

ASSISTANT RESIDENT ENGINEER

ASSISTANT RESIDENT ENGINEER required for a period of two years at £900 per annum. Large extensions are under construction at the Board's works at Dartford. The position affords an opportunity to candidates who require practical experience before professional interview to complete qualification as A.M.I.C.E.

Applications, giving full personal details, particulars of education, training and experience, and the names and addresses of two referees, must reach me within ten days after publication of this advertisement.

A. J. W. JEFFERY,
Secretary of the Board.
20, Blyth Road,
Bromley, Kent. E9179

LIVERPOOL REGIONAL HOSPITAL BOARD

ASSISTANT ENGINEER

ASSISTANT ENGINEER (Mechanical) required on the staff of the Regional Engineer.

Applicants should be at least G.I.Mech.E. or A.M.I.H. and V.E., and have passed the appropriate Institution examination and able to conduct site surveys. Experience in the preparation of drawings and specifications for engineering equipment and heating and ventilating schemes is essential.

Salary scale: £700–£1015 per annum.

Starting salary dependent on age and previous relevant practical experience.

Applications, stating age, qualifications, experience, present and previous posts, with names and addresses of three referees (2 technical), to reach me at 55, Castle Street, Liverpool, 2, by 5th December, 1958.

VINCENT COLLINGE,
E9204 Secretary to the Board.

PUBLIC APPOINTMENTS

COMMONWEALTH OF AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

COAL RESEARCH SECTION

APPOINTMENT OF COAL PETROLOGISTS

Applications are invited for appointment to two positions of COAL PETROLOGIST with the Organisation's Coal Research Section located at North Ryde, New South Wales.

The appointees will carry out investigations on the miscroscopy of coals and cokes as part of the Section's programme of research into the production and use of metallurgical coke, as well as general work on the petrology of Australian coals. This research is of great importance to Australian industry and the successful applicants will be provided with every opportunity for using and developing the most recent microscopic techniques.

Applicants should possess a University degree in Science with Geology as a major subject or equivalent qualification. Considerable experience in the field of coal petrology would be advantageous.

Dependent upon qualifications and experience, appointment will be made within the salary range of Experimental Officer Grade II, £A1416–£A1686 p.a. or Experimental Officer Grade III, £A1786–£A2006 p.a. Salary for a female appointee would be £A170 p.a. less than the corresponding male rates.

Appointment will be conditional upon a satisfactory medical examination and confirmation of appointment carries with it Commonwealth Superannuation Fund or Commonwealth Provident Account Privileges.

Fares to Australia, including those of wife and dependent family, will be provided by the Organisation. Details may be discussed with the undersigned.

Applications quoting Appointment No. 480/272 and stating full name, place, date and year of birth, nationality, marital state, present employment, details of qualifications and experience, and of war service if any, together with the names of not more than four persons acquainted with the applicant's academic and professional standing, should reach the undersigned, from whom further particulars may be obtained, by the 20th December, 1958.

E. J. DRAKE,
Chief Scientific Liaison Officer.
Australian Scientific Liaison Office,
Africa House,
Kingsway, W.C.2. E9177

YORKSHIRE OUSE RIVER BOARD

ENGINEER'S DEPARTMENT

ASSISTANT MECHANICAL ENGINEER

Applications are invited for the post of an ASSISTANT MECHANICAL ENGINEER on the Chief Engineer's staff. Applicants should have passed the examinations of the Institution of Mechanical Engineers and have had some experience of the operation and maintenance of excavators, tractors, vehicles and other items of contractor's plant.

The salary will be in accordance with the Special Scale adopted by the National Joint Council for Local Authorities' Services—£750–£1030.

Further information and form of application may be obtained from The Engineer, Yorkshire Ouse River Board, 21, Park Square South, Leeds, 1.

E. W. WELLS, B.Sc., M.I.C.E.,
Engineer to the Board.
E9182

WEST KENT MAIN SEWERAGE BOARD

SENIOR ENGINEERING ASSISTANT

SENIOR ENGINEERING ASSISTANT (£780–£1060). (Special grade with London allowance.) Commencing salary according to ability. N.J.C. conditions of service. Local government superannuation. Qualifications: University degree in engineering or graduate membership of I.C.E. Work includes design of sewers and reinforced concrete structures.—Applications, giving full personal details, particulars of education, training and experience and the names and addresses of two referees, should reach me within ten days of the publication of this advertisement.

A. J. W. JEFFERY,
20, Blyth Road, Secretary of the Board.
Bromley, Kent. E9110

PUBLIC APPOINTMENTS

MINISTRY OF LABOUR AND NATIONAL SERVICE

ROYAL NAVAL SCIENTIFIC SERVICE

APPOINTMENTS

Royal Naval Scientific Service requires SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS for Establishments in London area, Baldock, Portsmouth, Portland, Poole, Greenock and Rosyth. Main requirements are about 25 vacancies for PHYSICISTS, ELECTRONIC ENGINEERS and MATHEMATICIANS in areas specified. The following particular vacancies also exist: MECHANICAL ENGINEER, for work on gas turbine problems in the London area. MECHANICAL ENGINEER for work on design and development of U/W devices in Portland area. METALLURGISTS for Rosyth and Poole. CHEMISTS (Physical and Inorganic), for Poole area, Baldock and London. Candidates must be normally natural born British subjects of natural born British parents, with at least First or Second Class Honours Degrees or equivalent high professional attainments. S.S.O.'s must have had at least three years' post-graduate experience and be not less than 26 years of age. Salaries: (men) S.S.O. £1190–£1410; S.O. £635–£1110 (London)—somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts.

Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting A98/8A. E8879

USK RIVER BOARD

ASSISTANT ENGINEER

Applications are invited for the position of ASSISTANT ENGINEER on scale A.P.T. I (£575–£725), with a car allowance on the Essential User Scale for a car not exceeding 1199 cc., and subject to the National Scheme of Conditions of Service. Applicants should have completed the period of practical training required by the Professional Institutions and preference will be given to applicants who have taken part of the examinations of the Institution of Civil Engineers, and who have had experience in River Board or land drainage work.

Applications should state the age, technical training and previous experience of the applicant and copies of two recent testimonials should be attached. Applications should be addressed to the undersigned, to be received not later than the first post on Monday, the 8th December.

The appointment will be a designated post for the purposes of the Superannuation Acts and will be subject to a medical examination. In the case of a married man, assistance may be granted towards approved removal expenses. The appointment will be terminable by one month's notice on either side.

G. McLEOD, M.I.C.E.,
Engineer to the Board.
"The Croft,"
Caerleon, Mon.
17th November, 1958. E9225

BRITISH TRANSPORT DOCKS

SOUTHAMPTON DOCKS

ENGINEERING ASSISTANT

British Transport Docks invite applications for two positions as ENGINEERING ASSISTANT, Southampton Docks. Preference will be given to Corporate Members of the Institution of Civil Engineers or Institution of Structural Engineers, but consideration will be given to applicants with extensive experience in civil engineering. Candidates should have had experience in the design of dock structures and buildings in steel and/or plain and reinforced concrete.

The starting salary for one of the posts will be £943 p.a. and for the other £1045 p.a., but applicants for the latter should also have had experience in graving dock design and construction. Superannuation fund and certain free travel facilities.

Applications, giving age, experience and qualifications, to the Chief Docks Engineer, British Transport Docks, Herbert Walker Avenue, New Docks, Southampton, Hants, to arrive not later than 2nd December, 1958. E9214

Classified Advts. continued on page 120

PUBLIC APPOINTMENTS

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

ALDERMASTON AND WOOLWICH COMMON

REQUIRE

ENGINEERS

Post 1 : ENGINEER (Main Grade) at Atomic Weapons Research Establishment, Woolwich Common, S.E.18.

To supervise a group of project engineers engaged in the development for production of experimental equipment in the electronic electro-mechanical and light engineering fields. To supervise staff engaged on planning for production.

A recognised apprenticeship or equivalent practical training in electronics and Corporate Membership of a Senior Professional Engineers' Institution are required. Candidates should also be fully conversant with modern organisation and production methods as applied to the manufacture of research equipment. (Ref. 2046/25.)

Salary : £1400–£1840 (including London allowance).

Post 2 : ENGINEER (Basic Grade) at Atomic Weapons Research Establishment, Aldermaston, Berks.

For the planning of new works construction, including radioactive and conventional laboratories and workshops with their ancillary plant and services. Co-ordination of mechanical, electrical and civil design efforts and preparation of contractual specifications.

A recognised apprenticeship and Corporate Membership of one of the Institutions of Civil, Mechanical or Electrical Engineers or equivalent bualifications required. General experience of quilding construction including installation of services and plant, is necessary. Experience of ventilation would be advantageous. (Ref. 2078.25.)

Salary : £815 (at age 25)–£1110 (at age 34 or over)–£1270.

For both posts there is a contributory superannuation scheme.

For the Aldermaston post only a house or, alternatively, substantial assistance with house purchase, will become available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at A.W.R.E., Aldermaston, Berks. Please quote appropriate reference number.

E9164

BRITISH RAILWAYS RESEARCH DEPARTMENT

DERBY

SCIENTIFIC OFFICER GRADE 2

Vacancy at Derby for SCIENTIFIC OFFICER, Grade 2, in Engineering Division.

Candidates should have good Degree but previous research experience not essential.

Duties involve work on strength of materials and their fatigue resistance in relation to railway problems. Interest in photo-elasticity useful.

Salary : £665 to £985 (commencing salary according to qualifications and/or experience).

Superannuation and certain travel facilities.

Medical examination.

Applications, stating age, qualifications, &c, to :
Director of Research,
British Transport Commission,
(British Railways Division),
222, Marylebone Road,
London, N.W.1. E9203

BRITISH SHIPBUILDING RESEARCH ASSOCIATION

ATOMIC ENERGY SECTION

APPOINTMENTS

The British Shipbuilding Research Association has vacancies in its Atomic Energy Section for men aged about 25 with a good University Degree in Marine or Mechanical Engineering and with practical training and experience. Research experience an advantage. The persons appointed will be required in the first instance to work in the Association's team at the Atomic Energy Research Establishment, Harwell, studying the possible application of nuclear power to merchant ship propulsion. Experience of nuclear energy is not an essential qualification as training in this will be given. The commencing salaries will depend upon age and qualifications and the appointments are subject to the Federated Superannuation System for Universities.

Applications, with full particulars, should be addressed to : B.S.R.A., 5, Chesterfield Gardens, Curzon Street, London, W.1. E9187

MERSEY DOCKS AND HARBOUR BOARD

ENGINEERING ASSISTANTS

Applications are invited for the position of ENGINEERING ASSISTANT (2) for work on site of a major Docks reconstruction scheme now in progress at Liverpool.

Candidates should be Corporate Members of the Institution of Civil Engineers, although Graduate Members of the Institution would be considered.

The appointments—duration 2–3 years—will carry a salary of up to £1100 per annum according to qualifications and experience.

Applications stating age, qualifications and experience should be addressed to the Engineer-in-Chief, Dock Office, Liverpool, 3. Closing date December 1, 1958.

A. S. MOUNTFIELD,
General Manager and Secretary.

Dock Office,
Liverpool, 3. E9190

PUBLIC APPOINTMENTS

COMMONWEALTH OF AUSTRALIA
AUSTRALIAN DEFENCE SCIENTIFIC SERVICE

ENGINEERS

CIVIL MECHANICAL & ELECTRICAL

The Weapons Research Establishment of the Department of Supply, Adelaide, South Australia, invite applications for positions of ENGINEERS.

SUPERVISING ENGINEER (Position No. 145—Permanent).
SALARY : £2171/2336.
DUTIES : Engineering planning for major missile trials in Australia.
QUALIFICATIONS : Educational qualifications acceptable for admission to the appropriate professional institute. Honours degree in Engineering (1st or 2nd class) preferred. Extensive experience in planning major engineering works.

SENIOR ENGINEER (Position No. 157—Permanent).
SALARY : £1841/2006.
DUTIES : Engineering planning for missile trials.
QUALIFICATIONS : Educational qualifications acceptable for admission to the appropriate professional institute. Honours degree in Engineering (1st or 2nd class) preferred. Experience in Engineering planning.

SUPERVISING ENGINEER : (Position No. 155—Permanent).
SALARY : £2061/2226.
DUTIES : Supervise group engaged in design of radio, communication, timing, control and recording networks.
SENIOR ENGINEER : (A number of Permanent and Temporary positions).
SALARY : £1841/2006.
DUTIES : Supervise sections engaged in design in the fields of communication, electrical, electronic, materials or mechanical engineering or direct the activities of one or more of the following workshops, electrical, radio, electrofinishing, instrument or machine shop.

ENGINEER GRADE 3 (A number of Permanent and Temporary positions).
SALARY : £1506/1686.
DUTIES : Design in the fields of civil, communication, electrical, electronic, systems, materials or mechanical engineering, or supervision in one of the following workshops, electrical, radio, electrofinishing, instrument or machine shop.

ENGINEER GRADE 1 (A number of Permanent and temporary positions).
SALARY : £966/1416.
DUTIES : Similar to those of Engineer Grade 3, but at a lower level.

QUALIFICATIONS :
Minimum educational qualifications for all positions are those necessary to grant full exemption for corporate membership of the appropriate professional institute. Applicants for positions in the Electroplating shop may be qualified in chemistry or metallurgy in lieu of engineering. Applicants for Grade 3 or higher positions should have appropriate experience in one or more of the fields listed.

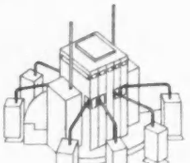
LOCATION :
All positions are located at Salisbury, a suburb of Adelaide, with the exception of Grade 3 Communication Engineers, who may be required to work for two (2) to three (3) years at Woomera.

NOTE :
First class sea/air fare for appointee and dependants (Wife and dependent children) will be paid under specific conditions by the Commonwealth. Assistance will be given in obtaining housing accommodation. (All salaries quoted are in Australian currency.)

APPLICATION forms obtainable from : Senior Representative (A.V.10/10), Department of Supply, Australia House, Strand, LONDON, W.C.2, with whom applications should be lodged by 8th December, 1958. E9210

DRAUGHTSMEN

POWER STATION DEVELOPMENT DESIGN & LAYOUT



The Southern Project Group have the following vacancies in their drawing-offices :—

Starting salaries within the following ranges :—

SECTION LEADERS (Mechanical and Electrical) : £1070 to £1170 per annum.

SENIOR DRAUGHTSMEN (Mechanical, Electrical and Civil) : £945 to £1045 per annum, £800 to £910 per annum.

ENGINEERING DRAUGHTSMEN (Mechanical and Electrical) : £635 to £755 per annum.

Candidates should have had a practical engineering training with experience in a drawing-office engaged on either the mechanical, electrical or civil work associated with modern power station construction.

N.J.B. conditions, superannuation, canteen, &c. (including site visits).

Ample opportunities to gain knowledge for advancement.

Appointments are available at the Group Headquarters, Squires, Lane, N.3, and at Ergon House, Lambeth Bridge, end of Horseferry Road, Westminster. The latter will be transferred to Finchley in about two years' time.

Applications, quoting "S.58.24," to (or on form from) :

CENTRAL ELECTRICITY GENERATING BOARD,
Southern Project Group Headquarters,
Squires Lane, Finchley, N.3.

E9211

PUBLIC APPOINTMENTS

UPPER WITHAM INTERNAL DRAINAGE BOARD

APPOINTMENT OF TEMPORARY ASSISTANTS

Applications are invited for the following appointments for a minimum period of two years, successful candidates to be engaged on the preparation and supervision of land drainage pumping schemes.

(a) DESIGN ASSISTANT, salary within Special Grade (£750–£1030) according to qualifications. Candidates should preferably have had experience of land drainage work. An allowance will be paid for the use of a car not exceeding 10 h.p. or 1119 c.c.

(b) DRAUGHTSMAN SURVEYOR, salary in accordance with A.P.T. Grade 1 (£575–£725) commencing salary to be fixed according to experience.

Applications stating age, qualifications, experience, particulars of present employment and when the applicant would be free to take up employment, accompanied by copies of testimonials, should be made to the undersigned not later than Saturday, 13th December, 1958.

J. BARNATT, A.M.I.C.E., A.M.I.W.E.,
Engineer to the Board.

20, Orchard Street,
Lincoln. E9181

TENDERS

STATE ELECTRICITY COMMISSION OF VICTORIA,

22, WILLIAM STREET,

MELBOURNE, VICTORIA, AUSTRALIA

400MW THERMAL POWER STATION STAGE 1 HAZELWOOD POWER STATION

The Commission is inviting TENDERS for the DESIGN, MANUFACTURE, SUPPLY, DELIVERY, ERECTION and MAINTENANCE of :—

BOILER PLANT and BUILDINGS and COAL HANDLING PLANT, all in accordance with Volume 1 (Introduction and General) and Volume 2 (Boiler Plant and Buildings and Coal Handling Plant) of Specification No. 58–59/73 and B.6 Contract Conditions.

Copies are available from the Agent-General for Victoria, Victoria House, Melbourne Place, Strand, London, W.C.2, and also from the Purchasing Branch of the Commission, 22, William Street, Melbourne, Australia.

The charge for specifications is £1 each volume (returnable) for the first copy. Each additional copy £1 (not returnable).

Volume 3 (Turbo-Generator Plant, &c.) and Volume 4 (Generator Transformers, Switchgear, &c.) of this specification will be issued during December, 1958.

Consideration will be given to comprehensive offers from single contractors or groups of contractors for a complete power station. Such offers shall include all foundations, the circulating water system within the turbine house and all concrete work, including floors, the turbine house building, control room and offices, and all auxiliary transformers, switchgear, power and control cabling and the relay house.

Tenders, endorsed "Tender to Specification No. 58–59/73," are returnable direct to the Commission, 22, William Street, Melbourne, Victoria, Australia, by 11 a.m. on the 29th April, 1959.

The Commission does not bind itself to accept the lowest or any offer. E9212

CITY OF BELFAST

BLACKSTAFF RIVER IMPROVEMENTS

TENDERS are invited for the EXECUTION of the following WORKS to improve the Blackstaff River in the City of Belfast :—

(a) The Construction of a Storm Relief Culvert between the Blackstaff River and the River Lagan. The length of the culvert will be approximately 1¼ miles, of which ½ mile will be constructed in tunnel, shield driven in compressed air, and ¼ mile in cut and cover. Cut and cover portions will consist of reinforced concrete box culvert of 144 sq. ft. section, and the tunnel portion will be lined with bolted reinforced concrete segments and have a finished diameter of 13ft.

(b) The Construction of Intake Works, Laying of New Sewers and the Construction of approximately 1150 lin. yds. of Stone Pitched Open Channel for the Blackstaff River, together with various Ancillary Works.

Contractors when tendering should submit particulars of their experience in tunnelling in compressed air.

Form of Tender, drawings, specification, bill of quantities and general conditions may be obtained at the City Surveyor's Department (Room 92), City Hall, Belfast, or from the Consulting Engineers, Sir William Halcrow and Partners, MM.I.C.E., Stanhope Street, 47, Park Lane, Westminster, London, W.1, after payment at the Chief Cashier's Office, City Hall (Room 29), Belfast, or at the office of the Consulting Engineers, of a deposit of £10 10s., which amount will be refunded provided a bona-fide Tender is lodged and not withdrawn.

Each Tender, in sealed envelope provided and endorsed with the name and address of the tenderer, must reach the undersigned not later than 4 p.m. on Monday, 23rd February, 1959.

An official receipt must be obtained for each Tender delivered by hand.

Tenders sent by post should be registered.

The lowest or any Tender will not necessarily be accepted.

JOHN DUNLOP,
Town Clerk.

City Hall, Belfast,
P.O. Box 234,
12th November, 1958. E9217

TENDERS

KINGDOM OF THAILAND

ROYAL IRRIGATION DEPARTMENT

BANGKOK, THAILAND

The Royal Irrigation Department of the Kingdom of Thailand requests sealed written BIDS for FURNISHING and DELIVERING F.O.B. contractor's shipping point for the Bhumiphol Dam, Yanhee Multipurpose Project, Kingdom of Thailand, in accordance with the contract documents. Invitation for Bids, No. YS-4-3, the following material :

Approximately 386,000 kilograms (Aluminium) or 948,000 kilograms (steel) of METAL TUBING and FITTINGS for concrete cooling and grouting systems.

Bids will be opened at 10.00 a.m., 22nd January, 1959. Copies of the contract documents, invitation for Bids, No. YS-4-3, may be obtained by qualified Bidders on written request on Bidder's letter head, addressed to Royal Irrigation Department, Attention: Thai Liaison Engineer, c/o Engineering Consultants, Inc., 1940, West Mississippi Avenue, Denver 23, Colorado, U.S.A. Each request must be accompanied by a cheque or money order, payable to the Royal Irrigation Department, in the amount of U.S. $5.00 for each copy of the contract documents requested.

M. L. XUJATH. KAMBHU,
Director General,
E9202 Royal Irrigation Department.

TENDERS

INDIA STORE DEPARTMENT

SINGLE-COLUMN ECCENTRIC PRESS

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of:

200-ton capacity, SINGLE-COLUMN ECCENTRIC PRESS for rail coach factory ; throat 500mm.; distance between table and ram maximum 550mm.

Please quote reference No. 18067/1/AKR/HAL.

The Tender forms with schedules and specifications, which are returnable on Thursday, the 18th December, 1958, may be obtained from the above office (C.D.N. Branch) on payment of a fee (which is not refundable) of ten shillings for each Tender. Applications for Tenders should clearly state the reference numbers of the Tenders required. E9165

EDUCATIONAL

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E114 E

BOOKS and PUBLICATIONS

HMSO

Heat Transfer in Deep Underground Tunnels

by A. W. PRATT *and* L. F. DAWS

The ventilation and air-conditioning of underground spaces is of economic interest to many industries. The need for further information on this subject prompted the investigation described in this paper. **3s.** (*post* 4*d*.)

Research in 1957

Additions to the annual series of reports from the specialised organisations of the Department of Scientific and Industrial Research.

Building Research **Hydraulics Research**

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KEMPE'S

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SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A DESIGNER DRAUGHTSMAN (MECHANICAL) is required by MICHELIN TYRE COMPANY, LTD., for interesting project work at their Stoke-on-Trent factory.

Applicants should have served a sound engineering apprenticeship in this country, possess H.N.C. (with Heat Engines, Applied Thermodynamics, or Steam Engineering endorsement preferred) and have had experience of problems involving steam and industrial hydraulic applications.

The appointment is permanent and pensionable. A 5-day 40-hour week and 3 weeks' annual holiday in force.

Housing assistance given if necessary. Tax free allowance of £4 a week for married men pending removal. Company pays removal charges.

Please write to MICHELIN TYRE COMPANY, LTD. (SPA Dept), STOKE-ON-TRENT, STAFFS, quoting Reference B/305/TE.

E9209 A

A STRUCTURAL ENGINEER is required by Markham and Company, Ltd., to be responsible directly to the Chief Engineer for the technical supervision of structural work at all stages. Minimum qualifications Higher National Certificate or preferably a degree. Familiarity with colliery headgear and associated types of work would be an advantage. —Applications, to include age, details of education and positions held with salaries earned, should be addressed to the Personnel Manager, MARKHAM AND COMPANY, LTD., Broad Oaks Works, Chesterfield. E9175 A

AN INTERESTING TECHNICAL SALES POSITION is available on the staff of a large industrial concern in Lancashire. The position involves sales and technical liaison work in connection with the distribution of a specialised range of products used mainly in plant maintenance. A considerable amount of travelling is necessary to visit factories in the U.K. and contacts will be mainly with technicians. Applications are invited from qualified engineers in the 30-40 age group who have a knowledge of chemical processing, steam and hydraulics, and are interested in Sales work. The position offers an interesting and well-paid career and there are opportunities of promotion within a large expanding organisation.—BOX No. E2195, "The Engineer." A

AN ORGANISATION IN THE EAST MIDLANDS HAS A VACANCY for an ENGINEER with specialist experience of cutting tool development and investigations into machining problems. The successful applicant will be responsible for practical tests and studies of production difficulties. Commencing salary not less than £850 p.a.—Please send details of career and qualifications, to BOX No. E9169, "The Engineer." A

AERO/THERMO-DYNAMICIST, with experience of gas turbine design, preferably from aircraft industry. DESIGNER-DRAFTSMAN, preferably with gas turbine experience. DEVELOPMENT ENGINEER AND ASSISTANT TO MANAGING DIRECTOR, with gas turbine experience, alternatively ex-Service Engineer Officer. The above vacancies are for permanent positions where intelligence and initiative will be rewarded. Apply with full details.—BOX No. E9120, "The Engineer." A

BIRLEC HEATING DIVISION SALES DEPARTMENT WANT FURNACE DESIGN ENGINEER. Duties include discussion with customer and liaison with Engineering Department designers and estimators, and preparation of project and Tender Specifications. H.N.C. or Engineering Degree standard.—Apply to Personnel Manager (JMP), Birlec, Ltd., Tyburn Road, Birmingham, 24. E9215 A

CHIEF ENGINEER.—An engineer of Managerial status is required by the B.B. Chemical Company, Ltd., the "Bostik" people. Duties involve control of new constructions and plant maintenance. The position calls for an energetic man who readily accepts responsibility and the salary will be in accordance with age, experience and qualifications. Applicants should be under 45 years of age and well educated in Mechanical and Electrical Engineering and hold a recognised qualification. A comprehentive pension scheme is in operation.—Apply by letter giving full details to The Secretary, B.B. CHEMICAL CO., LTD., Leicester. E2191 A

COLVILLES LIMITED

have openings for first-class DESIGN DRAUGHTSMEN. Steelworks experience not strictly essential if applicant is otherwise fully qualified and adaptable.

Apply by letter to C.M.E. Department, Technical Offices, Motherwell, stating experience and technical qualifications.

E9051 A

DESIGN DRAUGHTSMEN required for mechanical design of nucleonic instruments. Pleasant working conditions. Excellent rates of pay.—Apply Chief Draughtsman, Isotope Developments, Ltd., Beenham Grange, Aldermaston, Berks. Tel.: Woolhampton 451. E9116 A

DESIGN ENGINEER required by Edinburgh firm for specialised design work involved in the development and application of new products. Applicants should have an engineering degree and a sound practical training. Work involves the application of advanced strength of materials. A knowledge of metallurgy would be an advantage but not essential. Maximum age preferred 35.—Reply, stating age and giving details of qualifications and experience to BOX No. E2194, "The Engineer." A

SITUATIONS VACANT

DEVELOPMENT ENGINEER, with ideas, required by progressive company in Birmingham area, specialising in Contractors' Plant and Motor Vehicles. Knowledge of Hydraulics essential. Excellent opportunity for alert man. Good salary and prospects ; non-contributory pension scheme. —Details, in confidence, to BOX No. E9171, "The Engineer." A

DRAUGHTSMAN experienced in the detailing and design of structural steelwork required by Company in the South of England. Only those with good experience of this type of work should apply. State salary required.—Reply to BOX No. E9213, "The Engineer." A

DRAUGHTSMAN REQUIRED with knowledge of Railway Switch and Crossing Work.—Apply in writing, giving details of experience, qualifications, age, references and salary required, addressed "Confidential," to the Manager, Isca Foundry Company, Ltd., Newport, Monmouthshire. E9207 A

ELECTRONICS ENGINEER

COURTAULDS, LTD., require a SENIOR ELECTRONICS ENGINEER for the Experimental Department of their Engineering Division in Coventry. Applicants should possess a degree or equivalent academic qualification and should have had several years' industrial or research experience. The appointment is pensionable and will qualify for Co-partnership benefits.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds, Ltd., 16, St. Martins-le-Grand, London, E.C.1, quoting reference number B.50.

E9101 A

ENGINEER (MECHANICAL).—Applications are invited from Engineers not over 35 years, who possess First Class M.O.T. Certificates (Steam). Willing to reside in or near London for duties in that area and to undertake three-monthly tours of inspections of boilers, pressure vessels, &c., in West Africa. Salary in accordance with age, previous experience, if any, plus expenses and allowances. Non-contributory pension scheme. Apply in own handwriting.—BOX No. E9056, "The Engineer." A

ENGINEER (Non-Resident), by Middlesex County Council, for Percy House, Isleworth, Middlesex (large home for aged). Required to take charge of and be responsible for, operation and maintenance of engineering installations, comprising Calloway and Cornish boilers, calorifiers, steam-driven circulating pumps, steam meter, &c., and usual central heating and domestic hot and cold water systems, steam cooking equipment, electric passenger lifts, power, lighting and sundry other installations. Should be conversant with installations to above and experienced in maintenance of same. Salary £655–£715 p.a.; 44-hour week. Established, pensionable subject to medical assessment.—Apply, giving full particulars and 3 referees, to Chief Welfare Officer, 1, Queen Anne's Gate Buildings, Dartmouth Street, S.W.1. Canvassing disqualifies. E9150 A

ENGINEERING DRAUGHTSMAN required for chemical plant play-out and design. Please apply stating age, experience and qualifications. A house can be made available to suitable applicant.—L. B. HOLLIDAY & CO., LTD., Deighton, HUDDERSFIELD. E2193 A

ENGINEERS FOR SOUTH AMERICA

Qualified English-speaking MECHANICAL ENGINEERS required for important positions in a large steam power station in South America. Applicants should be corporate members of The Institution of Mechanical Engineers or hold a University engineering degree or Higher National Certificate. They must have at least five years' experience in a responsible position in a steam station of 50MW or larger.

The positions are interesting and permanent, and carry a generous starting salary up to £4,000 per annum depending on experience.

Full details should be given of age, education, qualifications and experience, and applications addressed to : Messrs. Mackness and Shipley, Consulting Engineers, Parliament Mansions, Abbey Orchard Street, London, S.W.1. Reference 2409/C should be quoted.

Applications from abroad should be forwarded by airmail.

E9172 A

EXPERIENCED SALESMEN interested in permanent employment with prospects, are invited to apply for a preliminary interview.

Preferential consideration given to men with some mechanical aptitude between the ages of 28 and 40 years, whose experience covers selling to Industrial Organisations.

Appointment carries basic salary, car, expenses, contributory Pension Scheme with liberal life insurance policy after two years' service.

Applications should state age, details of past experience and if able to move to another area if required to do so.—BOX No. E9227, "The Engineer." A

EXPERIENCED DESIGNER DRAUGHTSMAN required for development work with specialists in boiler and heat exchanger field, W.C.2. area.—Write full particulars to BOX TE.892, c/o 191, Gresham House, E.C.2 E9205 A

Classified Advts. continued on page 122

SITUATIONS VACANT

ENGINEERING INSURANCE. Applications are invited from Mechanical Engineers not over 35 years of age, who, having served an apprenticeship with Crane and Lift Makers, have a sound theoretical and practical knowledge of Cranes, Lifts, Lifting Machines and their maintenance, and are qualified to Higher National Certificate standard, for a vacancy as ENGINEER SURVEYOR in the West Country. The position is permanent, pensionable, with salary scale of £735, rising to £1060 per annum, plus expenses and allowances. Apply in own handwriting.—BOX No. E9189, "The Engineer." A

FIRST CLASS DRAUGHTSMAN required East Anglia. Experienced General Engineering and Mechanical Handling. Good technical training and able to work with minimum supervision. Flat available if required. First class conditions. Superannuation.—Apply, stating age, experience and salary required to Technical Director, BOX No. E9142, "The Engineer." A

GENERAL ENGINEERING DRAUGHTSMEN (Senior), having experience in Machine Design and Works Layouts. A knowledge of works building design desirable but not essential. Technical education to at least O.N.C. Some assistance will be given with regard to house purchase in cases of successful applicants who are married.—Write, giving details of experience and stating age and present salary, to the Personnel Manager, FERODO LIMITED, Chapel-en-le-Frith, Via Stockport. E9185 A

GENERAL WORKS MANAGER required for engineering factory in Home Counties—general precision and aircraft components. Previous experience in large factory organisation essential. High salary and benefits to capable and experienced man. Send full details in confidence to Managing Director.—BOX No. E9162, "The Engineer." A

GRADUATE MECHANICAL ENGINEER.—Applications are invited from Graduate Mechanical Engineers who are interested in Mechanical Design problems of various machines and plant connected with the gas and chemical plant industries. The successful applicant would be expected to assist the Chief Design Engineer and should preferably have some knowledge of high pressure technique, mechanics, hydraulics and material design. The post will offer creative scope and an opening to a long-term career. Salary according to qualifications and experience.—THE POWER-GAS CORPORATION LTD., Stockton-on-Tees. E9178 A

HEAD WRIGHTSON IRON AND STEEL WORKS ENGINEERING LTD.

ELECTRICAL ENGINEER

Required for Resident Engineer's Staff on large development contracts in the Iron and Steel Industry. Applicants should preferably be Chartered Electrical Engineers, with suitable experience of installation work. Applications should state age, experience, qualifications and salary required, to: Personnel Manager, Ref. I.S.21, Teesdale Iron Works, Thornaby-on-Tees.

E9183 A

JUNIOR ASSISTANT MECHANICAL ENGINEER OR DRAUGHTSMAN wanted immediately. Must have good education, at least H.N.C. standard in Engineering, sound practical apprenticeship of not less than two years in engineering works, and preferably a year or so in a modern drawing-office. Experience on pumps, pipework, vessels and other chemical plant an advantage. Age preferably 24 to 28. Starting salary in range £600 to £900. Candidates on short list will be asked to attend for interview at Dublin, all expenses paid.—Please give full chronological particulars of education, training and posts held, to The Chief Engineer, ARTHUR GUINNESS SON AND CO. (DUBLIN), LTD., St. James's Gate, Dublin. E9157 A

LIFTING AND MECHANICAL HANDLING

An old-established Company with offices in West London have a vacancy for a TECHNICAL ASSISTANT for Inside Sales Work.

The post offers excellent prospects of advancement for a young man with some experience and an engineering background.

Write, giving details of age and qualifications. —BOX No. E9196, "The Engineer."

A

LLOYD'S REGISTER OF SHIPPING invite applications for appointment as ENGINEER TECHNICAL ASSISTANT for service first in London with transfer shortly to Croydon. Candidates should have drawing office experience and reasonable technical training. Mechanical engineering experience an advantage. Commencing salary dependent upon qualifications and experience.—Forward full particulars to The Secretary, Lloyd's Register of Shipping, 71, Fenchurch Street, London, E.C.3. E9173 A

QUALIFIED CIVIL ENGINEER required by Consulting Engineers, for position of ASSISTANT RESIDENT ENGINEER, to supervise construction of Port Works at Port Sudan. Salary according to experience and qualifications, married quarters available with heavy furniture, cost-of-living allowance and bonus. Duration about sixteen months. —Write, stating age and experience, to COODE AND PARTNERS, 2/8, Victoria Street, London, S.W.1. E9192 A

SITUATIONS VACANT

MECHANICAL ENGINEERS required for highly interesting new design and development work in the field of Converting Machinery for Paper and Board. Previous experience in this field, though desirable, is not essential but successful candidates must have solid academic and practical engineering background with sound knowledge of design, and be able to produce as well as evaluate new ideas. Modern works in S.W. London. Pension scheme. Good salary.—Applications, which will be treated in confidence, should include full particulars of training and experience.—Reply BOX No. E9174, "The Engineer." A

PERSONNEL REQUIRED

MANAGER required for Firm of Structural Steelwork Engineers employing about forty people. Applicants must have administrative capacity with a comprehensive knowledge of design, detailing, fabrication, welding and erection of Structural Steelwork. Works are situated near Liverpool. Attractive salary offered. Give full particulars of qualifications and previous experience.—BOX S 547, LEE AND NIGHTINGALE, LIVERPOOL. E9191 A

SALES ENGINEER required to represent the interests of a large firm of Engineers in Yorkshire. Must be qualified Engineer. Age 28/38. Sales experience not essential.—Apply for application form, giving brief details as to experience, age and salary expected to BOX No. E9224, "The Engineer." A

SENIOR STRUCTURAL DESIGNER AND A SENIOR DRAUGHTSMAN required by British Insulated Callender's Construction Company, Ltd., for the design of structural steelwork for Radio Masts and Towers, Unit Construction Bridges and other Special Purpose Structures. The company has a leading world position in this all-important field of communications, and the work is varied and interesting. High salaries commensurate with responsibilities are offered with five-day week, Pension Fund, Canteen, &c.—Apply by 'phone or in writing to the Personnel Officer (Staff), 21, Bloomsbury Street, London, W.C.1. (MUSeum 1600). E9220 A

TECHNICAL EDITOR required by rapidly expanding organisation in the East Midlands, for new group of journals covering many aspects of production and mechanical engineering. This appointment carries an excellent starting salary and offers considerable scope for development to a man with ability and energy. Superannuation scheme and pleasant surroundings. Send details of career and present salary.—BOX No. E9133, "The Engineer." A

THE LUMMUS COMPANY LIMITED

IMPERIAL HOUSE, 80, REGENT STREET, LONDON, W.1.

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY REQUIRE A

PUMP ENGINEER

for work in their London office, preferably with experience of refinery pumps and compressors. Work will entail preparing specifications and checking quotations and drawings. Finest working conditions. One minute from Piccadilly Circus. Five-day week. Sickness and pension schemes.

Apply by letter to the Personnel Officer.

E9180 A

SHELL

"SHELL" RESEARCH LIMITED

require

CIVIL OR MECHANICAL ENGINEERS

and

PHYSICISTS FOR RESEARCH

on the mechanical properties of bituminous mixes used in road construction and on problems relating to the design and construction of road structures. The work is at

THORNTON RESEARCH CENTRE near Chester

Applicants should preferably be not more than 30 years of age and should have a University Honours degree. Salary and prospects are good. We work a five-day week and there is an excellent pension scheme. Help with house purchase and removal costs from an established home can be provided for successful applicants.

Applications should be addressed to:—

STAFF DEPARTMENT R/B, "SHELL" RESEARCH LIMITED, 16, FINSBURY CIRCUS, LONDON, E.C.2. E9206 A

SITUATIONS VACANT

SENIOR TECHNICAL ENGINEER

A major industrial group has a vacancy for a SENIOR TECHNICAL ENGINEER to work in the Technical Department at the Head Office situated in London. The work is in connection with the investigation and development of new techniques and the efficiency of existing techniques.

This is a senior appointment and is an exceptional opportunity for a person with a good honours degree in Mechanical Engineering coupled with a good practical background.

The successful applicant must have a good personality and he must feel that he will be able to accept responsibility in the field of technical management later on.

Age range 30–33. Apply, stating full details of age, qualifications and experience. —BOX No. E9197, "The Engineer." A

SITUATIONS VACANT

GENERAL DESIGN DRAUGHTSMAN

for

BAHRAIN

APPLICATIONS are invited for this position with the Bahrain Petroleum Company, Limited, from men with Higher National Certificate in Mechanical Engineering and not over 35 years of age.

Duties involve necessary design calculations for work such as positioning and sizing expansion loops in process lines, sizing of structural members for support structures, calculating stresses in pressure vessels to determine allowable wall thicknesses, &c., and applicants must have a thorough knowledge of First and Third Angle and Isometric projection drawings, and of materials and methods of construction.

The commencing salary is £111.0.0. per month, in addition to which free air-conditioned accommodation and a living allowance are provided. An initial kit allowance, medical attention, paid local and home leaves are also provided with participation in Pension and Provident Fund Schemes.—Apply in writing, quoting "ETS," with full particulars of experience, to Caltex Services, Limited, Caltex House, Knightsbridge Green, London, S.W.1. E9105 A

SENIOR MECHANICAL ENGINEERING DRAUGHTSMEN

are offered progressive posts at

Stewarts and Lloyds Limited

Corby, Northants

in the

Tube Works Drawing Office

and the

Iron and Steel Works Drawing Office

Applicants should have Higher National Certificate and sound drawing-office experience in heavy engineering. The work involves layout, maintenance and improvement of plant and equipment.

Five-day week, good welfare, canteen and recreational facilities. Superannuation and life assurance scheme. Staff Hostel for single men. Excellent housing prospects. Good salaries based on experience and qualifications.

Applications will be treated as confidential and should give age, details of qualifications, experience, salary requirement and the department to which the application refers. They should be addressed to :—

Manager/Personnel,

Stewarts and Lloyds Limited,

Corby, Northants.

E9195 A

ENGLISH ELECTRIC

WHETSTONE NEAR LEICESTER

wish to appoint a

SENIOR MECHANICAL ENGINEER

in the Gas Circuit Section of the

ATOMIC POWER DIVISION

The successful applicant will be required to handle problems in Fluid Flow and Heat Transfer associated with the design of pressure systems.

Applicants should be Graduate Engineers with Corporate Membership of a Senior Institution. Knowledge of pressure vessel practice and standard codes would be valuable.

The appointment carries a considerable responsibility, and an ability to conduct discussions with clients and sub-contractors is a definite requirement.

Please write, giving details of qualifications and experience, to : Dept. C.P.S., Marconi House, 336/7, Strand, London, W.C.2, quoting reference E 1817E.

E9221 A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of a

CHIEF ENGINEER BLAST FURNACE CONSTRUCTION

for a soundly established and thriving company in N.W. England which is developing its subsidiary engaged on blast furnace construction.

The man appointed will be responsible to the Managing Director for all aspects of the subsidiary company's operations including design and supervision of blast furnace erection, pricing and negotiating contracts.

Commencing salary up to £2,500, according to experience, with an opportunity of a directorship within two years. Car provided. Superannuation. Assistance with house removal.

Candidates must have had several years' experience on design and estimating for blast furnace construction and should also have experience of contract negotiation.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1384, to W. F. Younger.

MANAGEMENT SELECTION LIMITED

17, Stratton Street, London, W.1.

E134 A

SITUATIONS VACANT

MSL have been retained to advise on the appointment of

WORKS ENGINEERS

for the factories of a company engaged in the food processing industry.

Two engineers are required to be responsible to the Chief Engineer for the layout, planning, installation and maintenance of canning plant and food processing machinery in two groups of factories.

One group of 3 factories is situated in Northern Ireland, the other 2 factories are in South West Scotland, and the Engineers will be expected to play full parts in the technical contribution to the company's programme of expansion.

Applicants should have degrees or equivalent qualifications in mechanical engineering and must have had at least five years' experience in a responsible executive position in a company within the food industry. They should have a knowledge of steam generating plant. The appointment in Northern Ireland calls additionally for knowledge and experience of large scale refrigeration plant ; that in Scotland for experience of high speed canning machinery.

Initial salary £1,600. Car provided. Age range 30 to 40.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G.1356, to G. K. Dickinson.

MANAGEMENT SELECTION LIMITED

17, Stratton Street, London, W.1.

E140 A

SITUATIONS VACANT

THE BANK OF ENGLAND PRINTING WORKS

require a

DESIGNER-DRAUGHTSMAN

(A.M.I.Mech.E. or H.N.C.)

aged under 35, with experience of process machinery, to join a technical team engaged on the development of special-purpose printing and packaging machinery. Pensionable appointment. Starting salary up to £1250 per annum. Write, stating age and qualifications, with full details of previous career, to :

The Staff Manager,
Bank of England Printing Works,
Langston Road,
Loughton, Essex.

E9200 A

SITUATIONS VACANT

PILKINGTON BROTHERS LIMITED

GLASS MANUFACTURERS

RESEARCH AND TECHNICAL DEVELOPMENT ASSISTANTS

Several interesting vacancies have arisen as a result of continuing expansion and the recent appointment of graduate engineers, physicists and chemists.

Duties vary from fundamental research on the materials and methods of glass manufacture, and on the physical, chemical, electrical and mechanical properties of glass, to the technical design and application of instruments, apparatus and plant, to improve existing methods and to develop new processes and products.

If you are in the 25–30 age group, have a Higher National Diploma or Certificate and some experience of heavy industry, you are invited to apply to the Personnel Officer (Graduate Recruitment), Pilkington Brothers Limited, St. Helens, Lancs.

E9198 A

BRITISH OXYGEN ENGINEERING LIMITED

SITE ENGINEER

Applications are invited for an appointment as a Site Engineer with the Company's Construction Group, entailing responsibility for the erection and installation of large air separation and chemical plant.

Applicants should be of Degree or equivalent standard and preferably have had previous site experience, covering mechanical and electrical installations, and be capable of supervising direct and sub-contract labour.

Sites will be located in the U.K. with opportunities for overseas operations.

Applications, giving full details of age, qualifications and experience to :—

The Personnel Manager (GH 23),

BRITISH OXYGEN ENGINEERING LIMITED,

Angel Road, Edmonton, London, N.18.

E9219 A

THE NELSON RESEARCH LABORATORIES

OF

THE ENGLISH ELECTRIC COMPANY LIMITED

FRICTION AND SOLID STATE PHYSICS

Excellent opportunities are available for PHYSICISTS and ENGINEERS WITH AN INTEREST IN PHYSICS for the following interesting work :—

(*a*) Investigations into the wear and friction characteristics of rubbing surfaces on a fundamental basis.

(*b*) Research on various aspects of solid state physics, including fundamental work on magnetism and semi-conductor materials.

Previous experience in these fields is not essential, but a sound basic knowledge is required.

HEAT TRANSFER

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E9168 A

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December 2-3	**Machine tools and miscellaneous stores,** including :—	M.O.S. Storage Depot, **Byley, Middlewich, Cheshire.** (Sale at New Islington Public Hall, Ancoats, Manchester.)	**J. H. NORRIS & SON** (Dept. L), 9, Albert Square, Manchester, 2. (Tel. : Blackfriars 8373.)

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December 5	**Miscellaneous stores.**	Returned Stores Group, Reed Hall, **Colchester.**	**FENN, WRIGHT & CO.** (Dept. L), 146, High Street, Colchester, Essex. (Tel. : 3171.)
December 9	**Miscellaneous stores.**	M.O.S. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel. : 47271.)
December 16-18	**Miscellaneous stores.**	M.O.S. Storage Depot, **Royal Arsenal, Woolwich S.E.18.**	**FULLER, HORSEY, SONS & CASSELL** (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel. : Royal 4861.)

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Tenders to be submitted by December 8.

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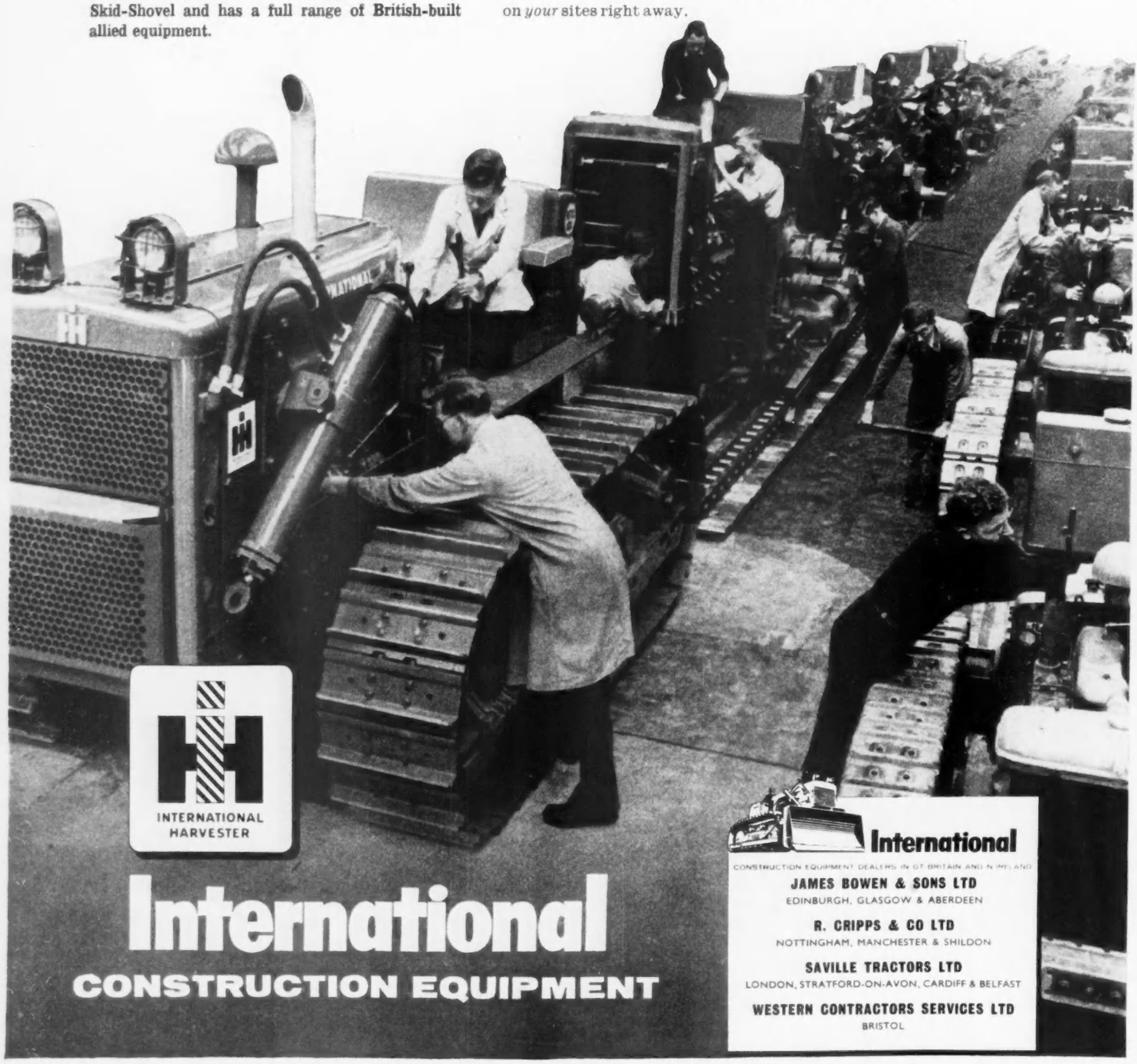

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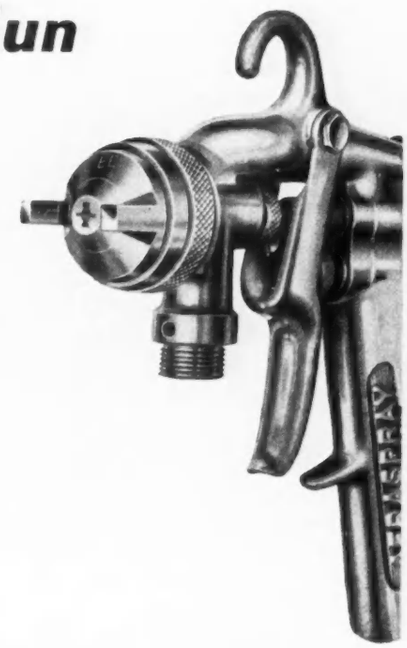

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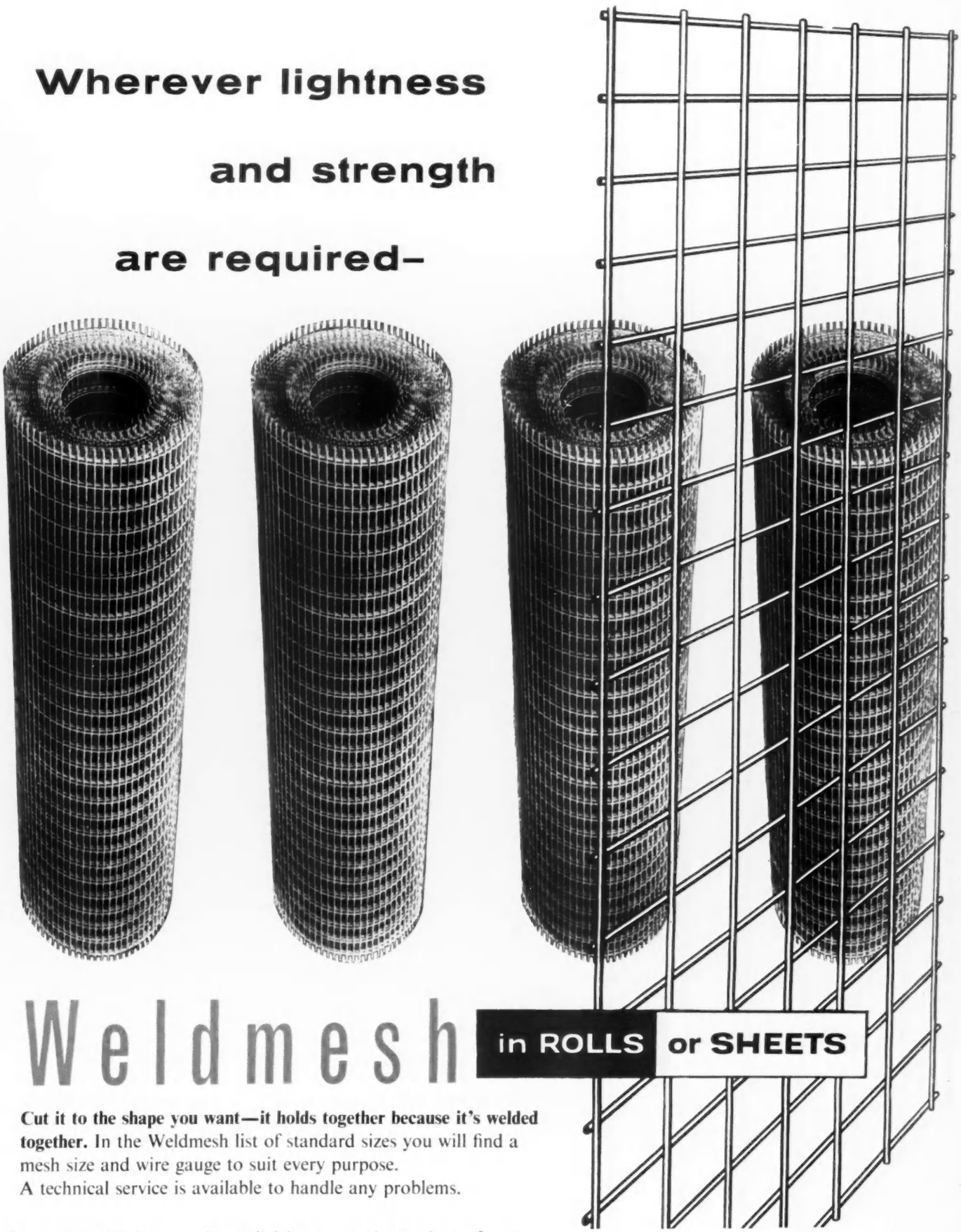

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The Engineer

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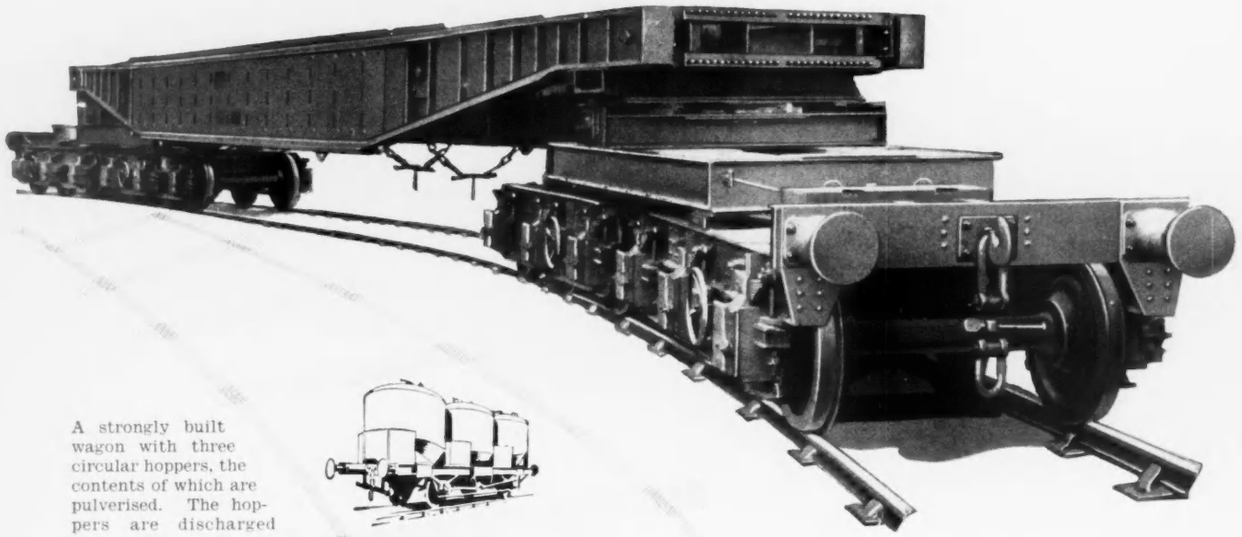
rolling stock



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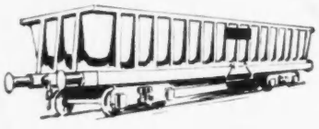
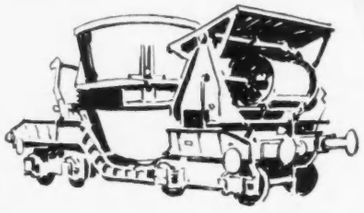
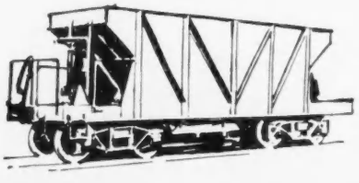


A welded steel carriage carrying a 400 cu. ft. Treadwell tipping slag ladle. Tipping is effected by means of steam or air.



Another example from the extensive range of Head Wrightson rolling stock, this bogie hopper wagon carries 40 tons and has transversely hinged doors.



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